

Variations in Raindrop Concentration and Size Distribution on the Olympic Peninsula during the Nov 12-13 Heavy Rain Event



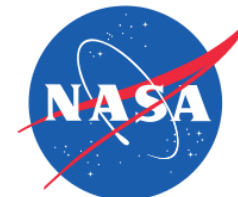
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Pacific Northwest Weather Workshop 4 March 2016

NASA grants: NNX13AG71G, NNX15AL38G, and NNX16AD75G

NSF grants: AGS-1503155



Nov 12-13: Widespread extreme rainfall totals

OLYMPEX 48-h Precip (mm) 12-13 Nov 2015

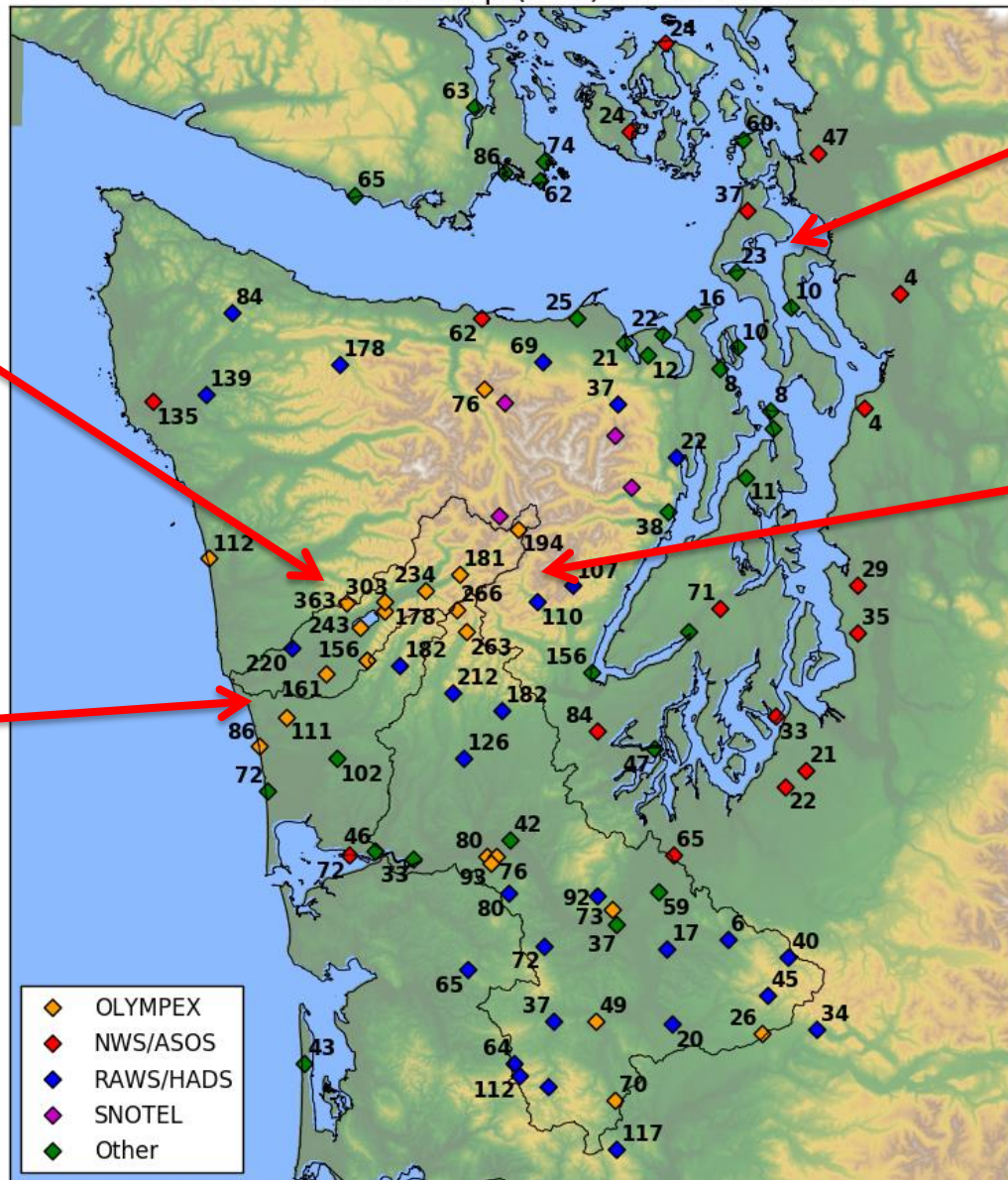
303 mm at CRN site just north of Lake Quinault

363 mm at 1,700 ft on ridge NW of lake

Gradient of increasing rainfall totals moving inland

The famous rain shadow!

175-275 mm farther up Quinault Valley and in Wynoochee area

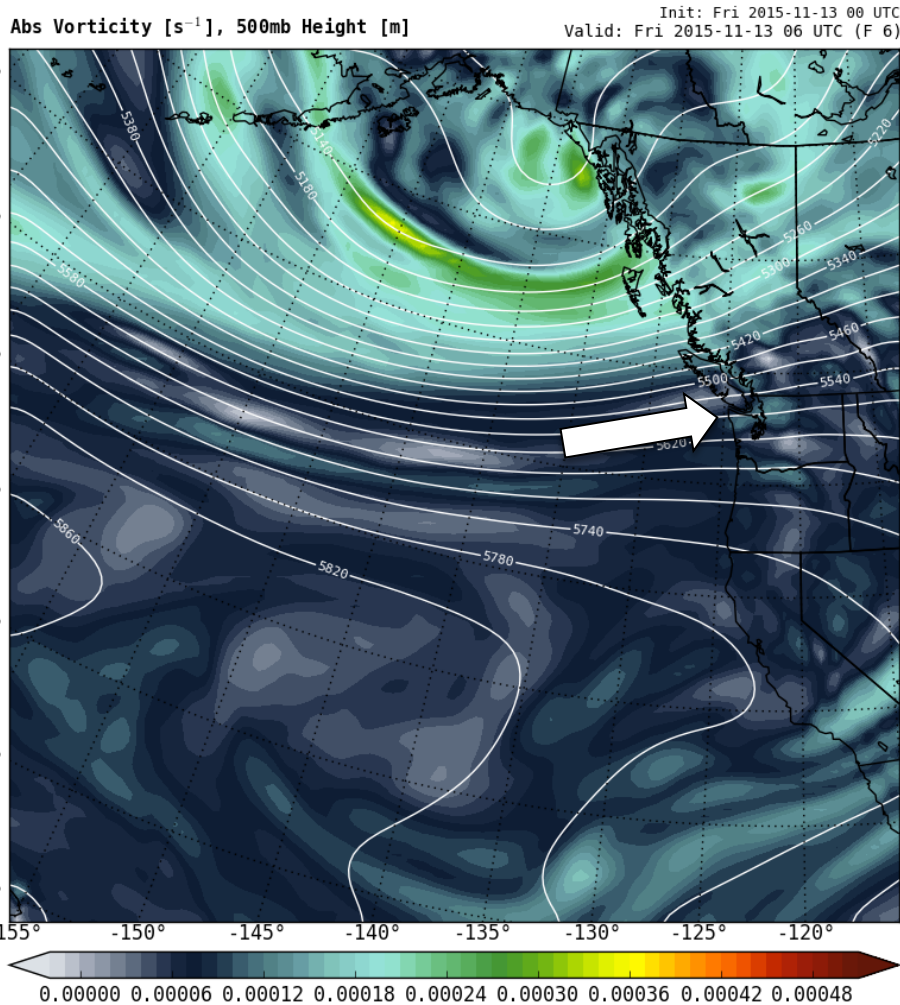


Goal of this presentation

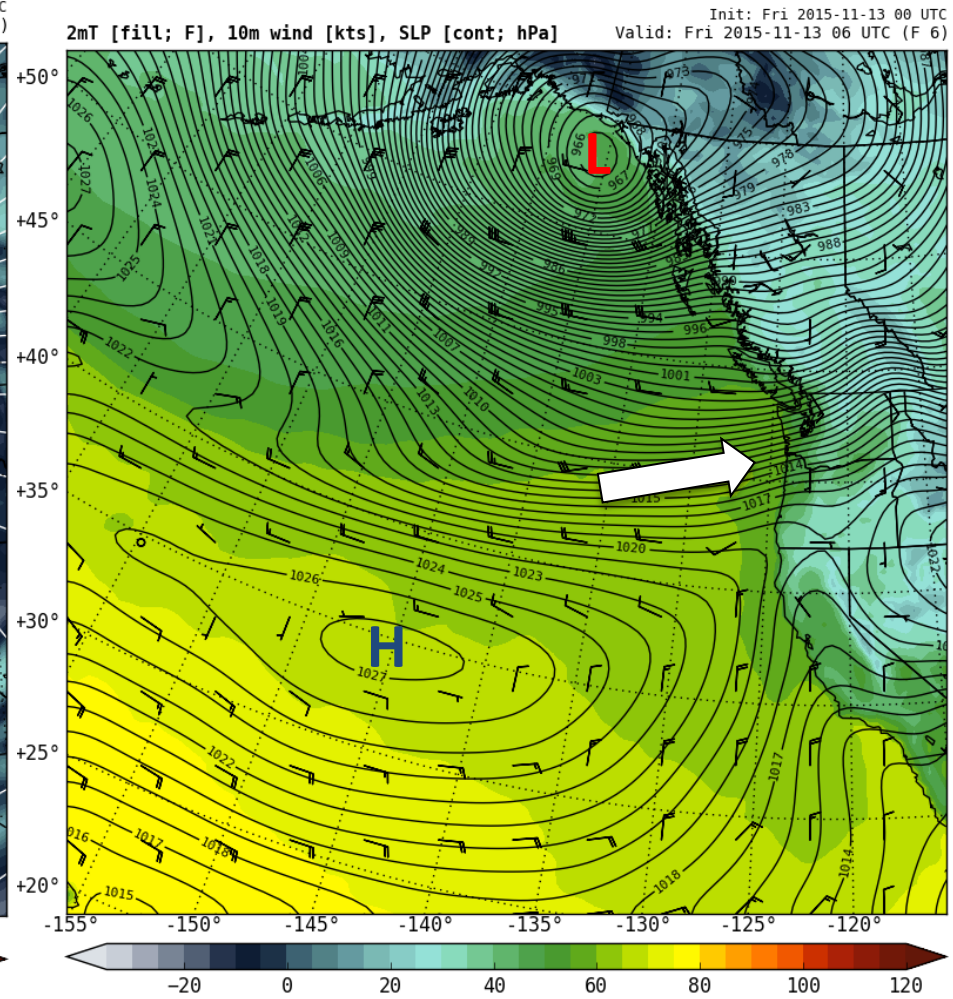
Explain the differences in rainfall distribution using the various measurements from OLYMPEX

Nov 12-13 0600 UTC

500 hPa Height (lines), Vorticity (contours)

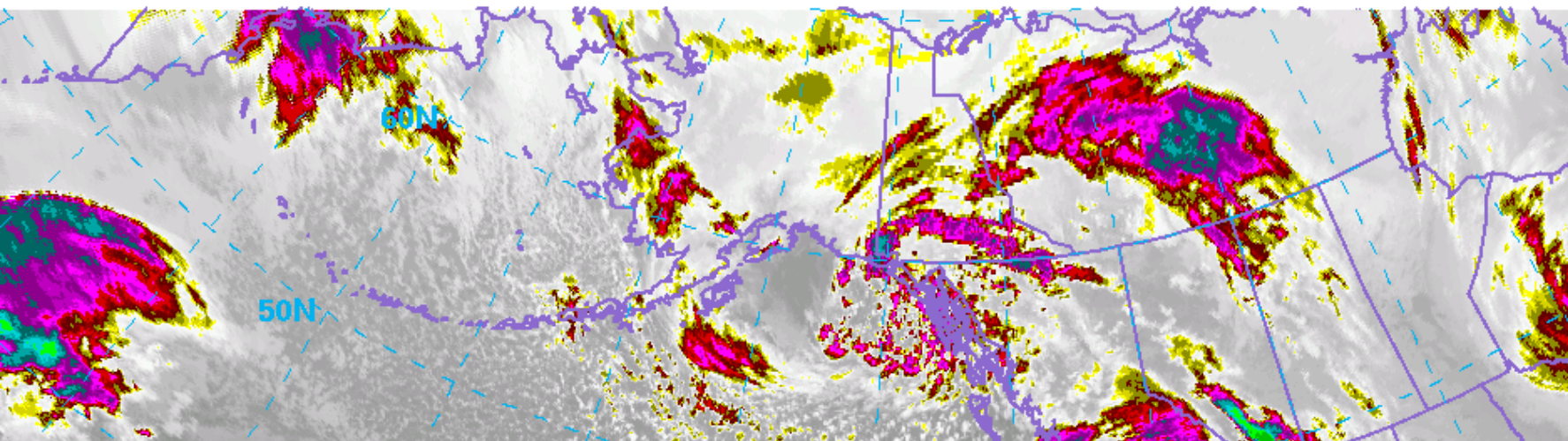


Surface Pressure (contours), Temp (colors)

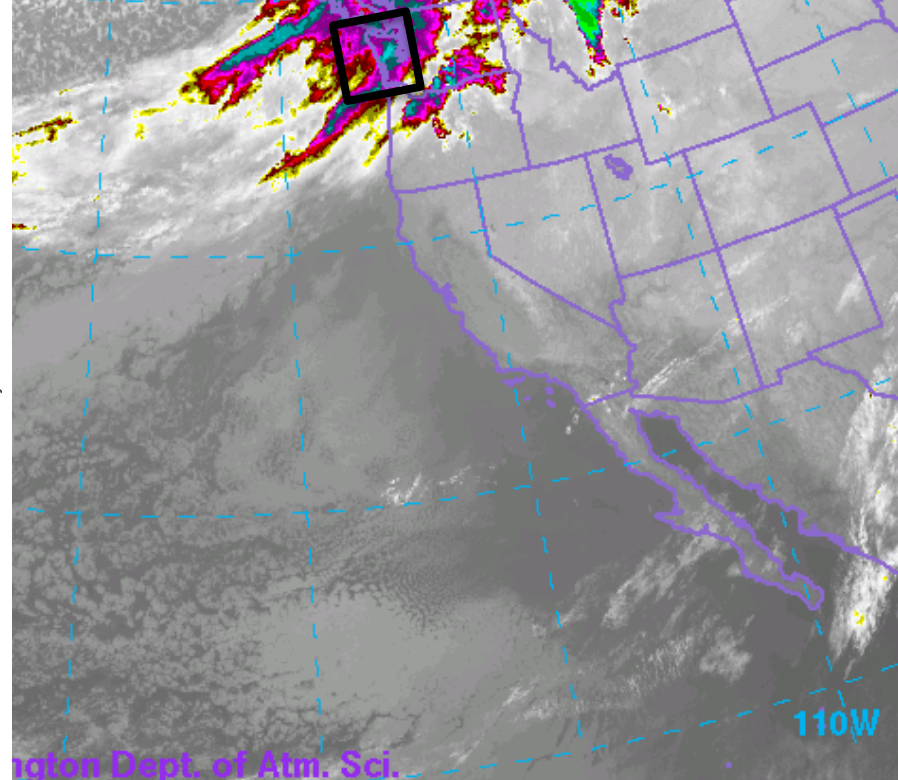
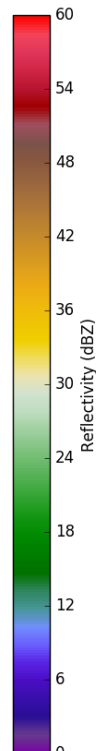
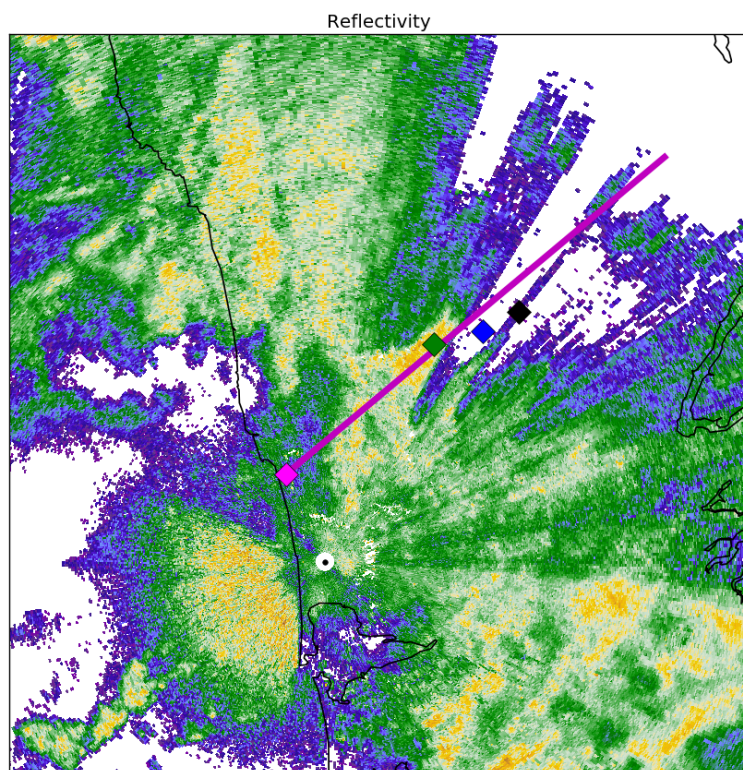


“Westerly Atmospheric River”

IR 06:00Z Fri 13 Nov 2015

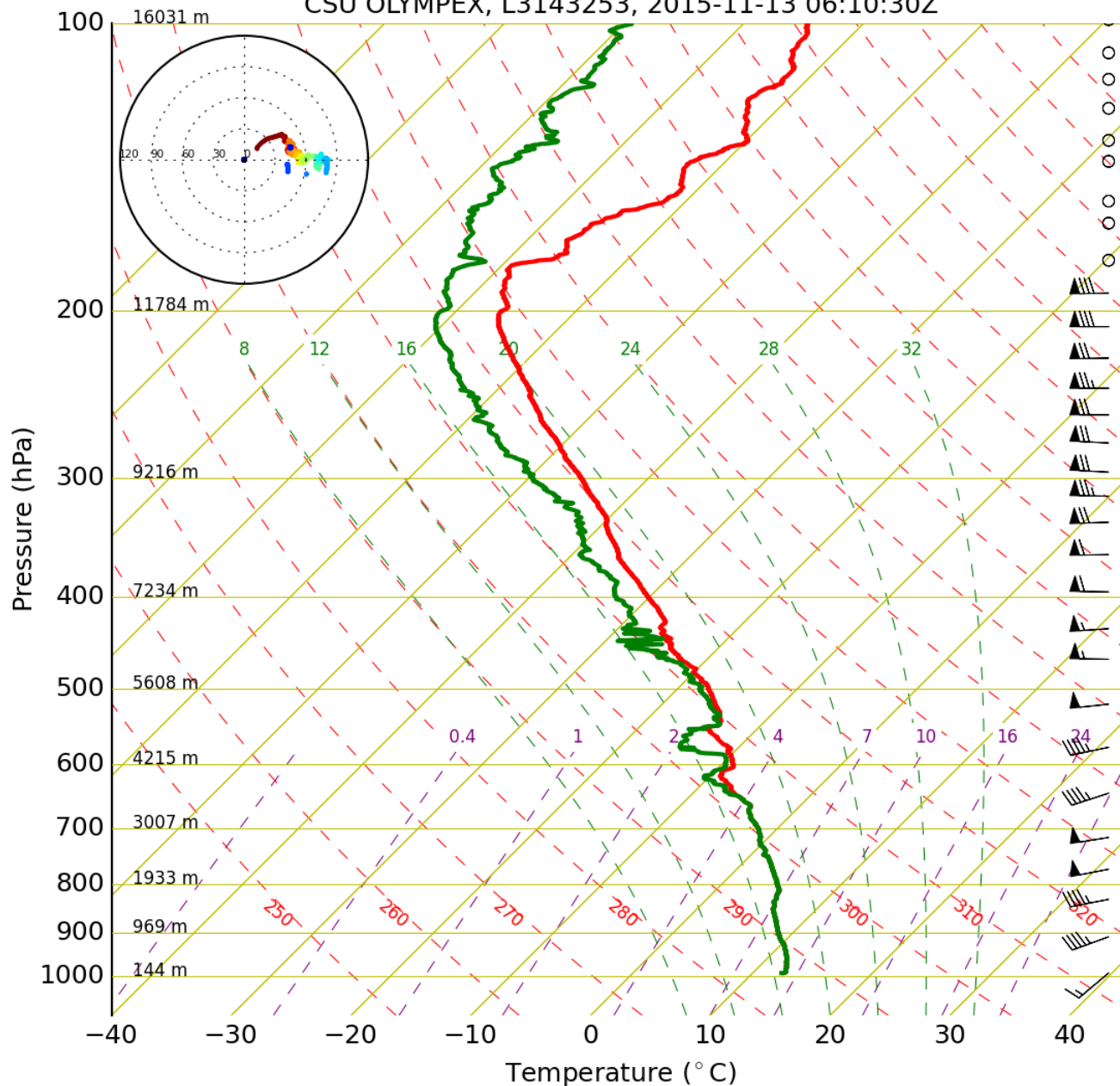


PPI KLGX 2015-Nov-13 06:04 UTC Elev 0.18°



NPOL Sounding 0600 UTC 13-Nov

CSU OLYMPEX, L3143253, 2015-11-13 06:10:30Z



Sounding Params

0°C: 2680 m
-20°C: 5903 m
-40°C: 8530 m
LCL: 43 m
PW: 29.3 mm
6 km shear: 41 kts
Tropopause: 201 hPa

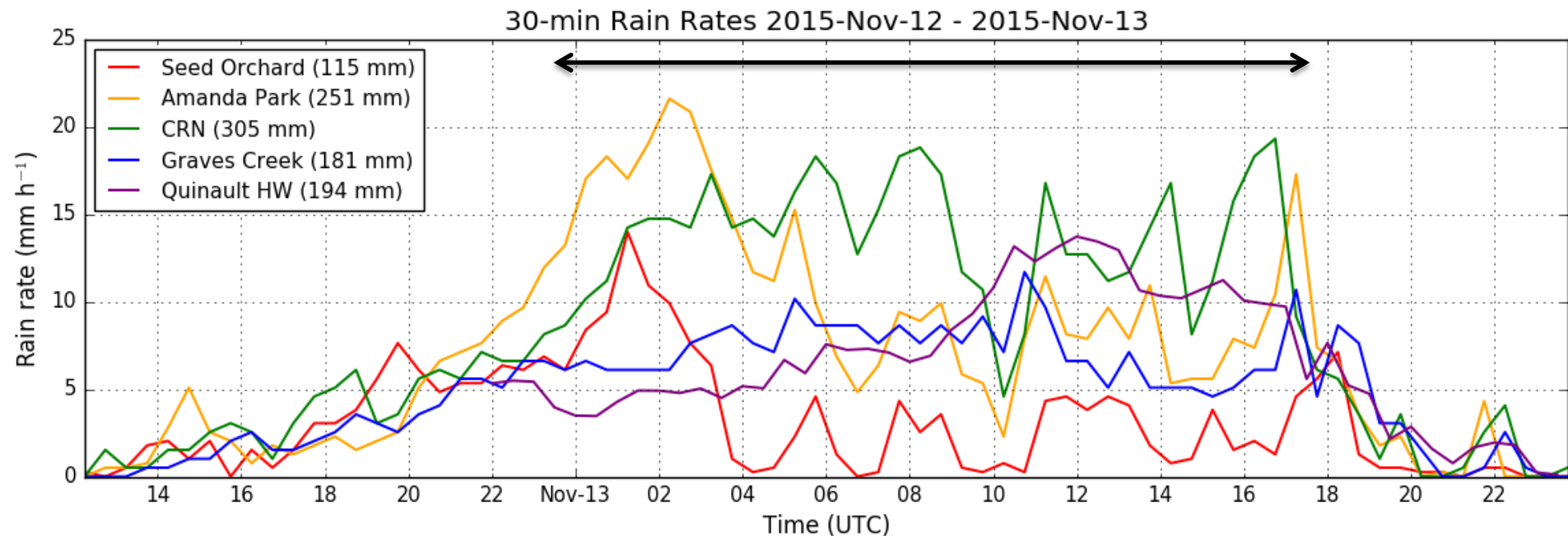
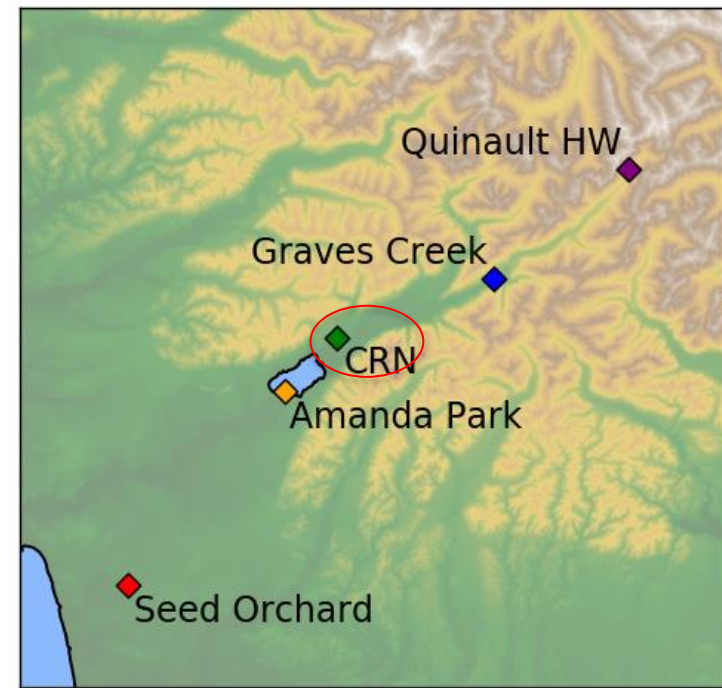
45 kt wind at
925 hPa

Nov 12-13

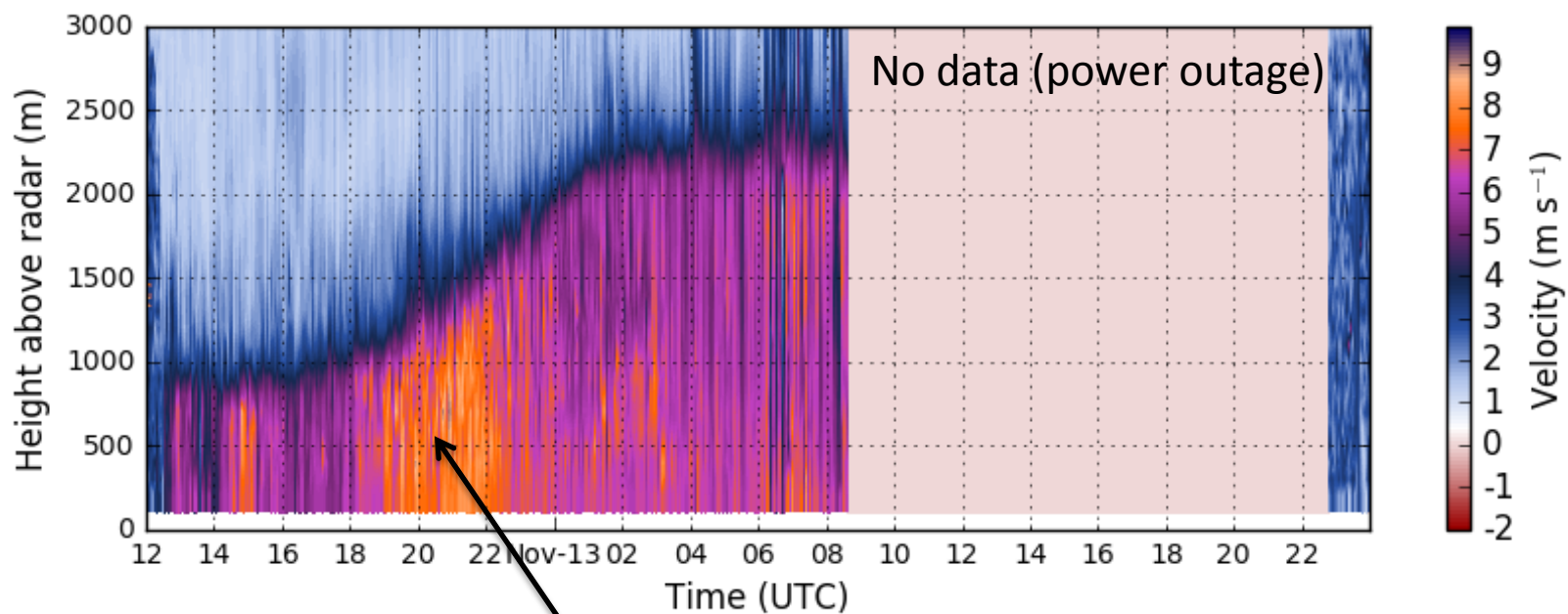
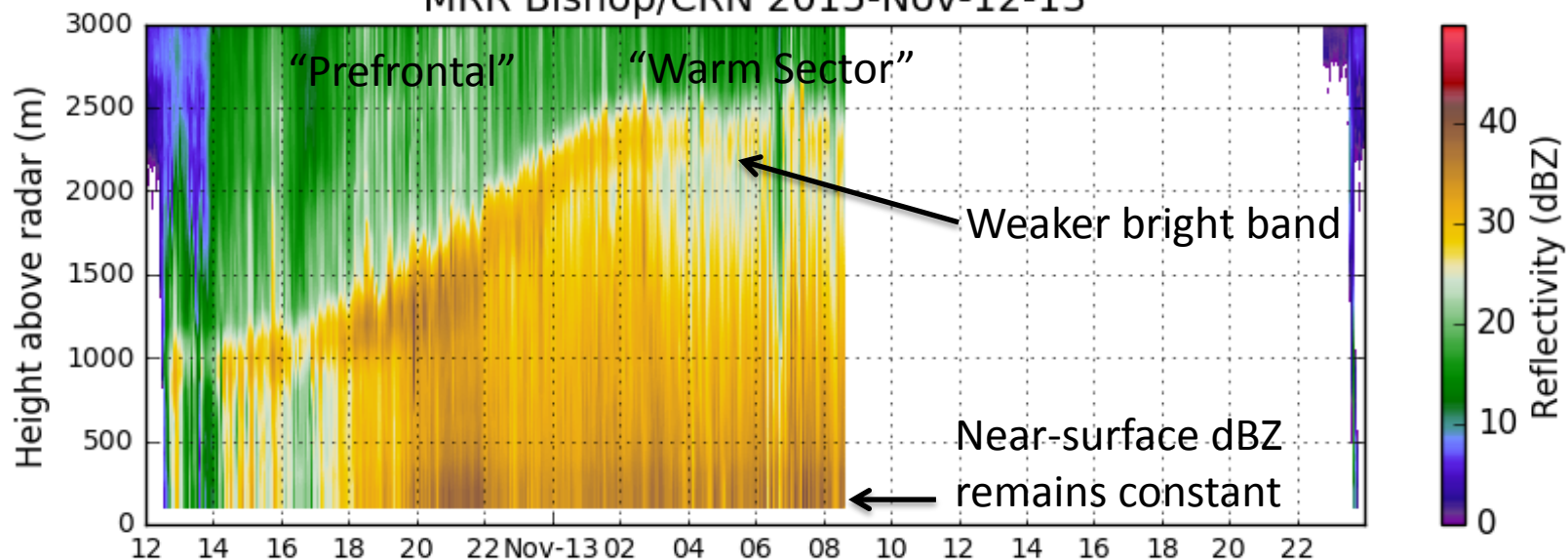
Rain rates

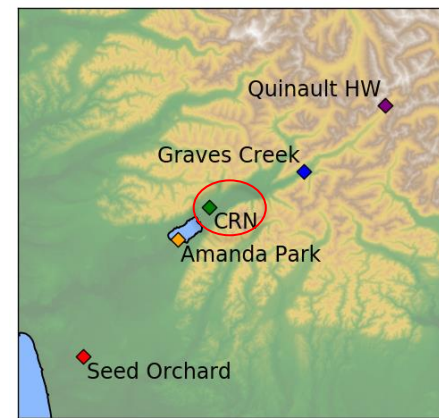
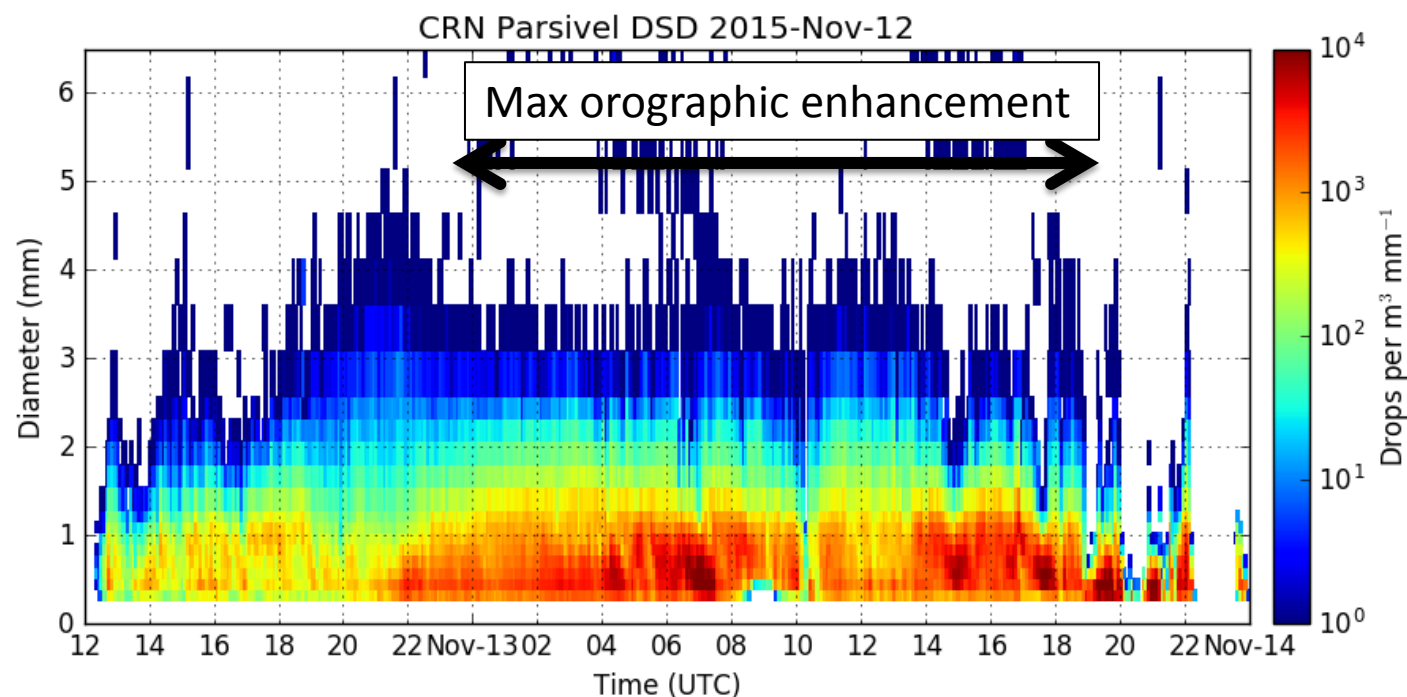
18 hour period of orographic enhancement
starting around 00 UTC 13-Nov

More rain at low-elevation CRN site compared
with interior sites (Graves Creek, Quinault HW)

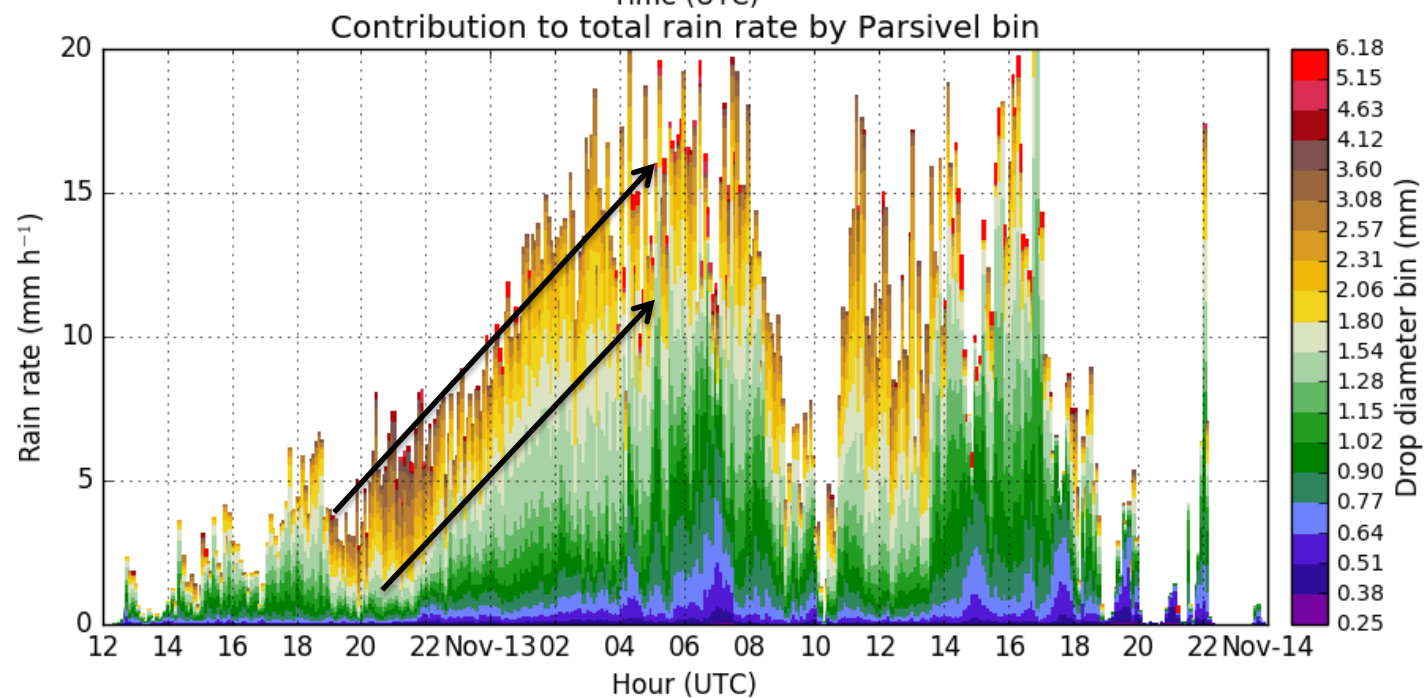


MRR Bishop/CRN 2015-Nov-12-13

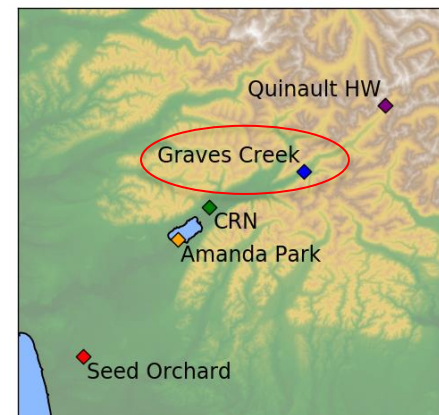
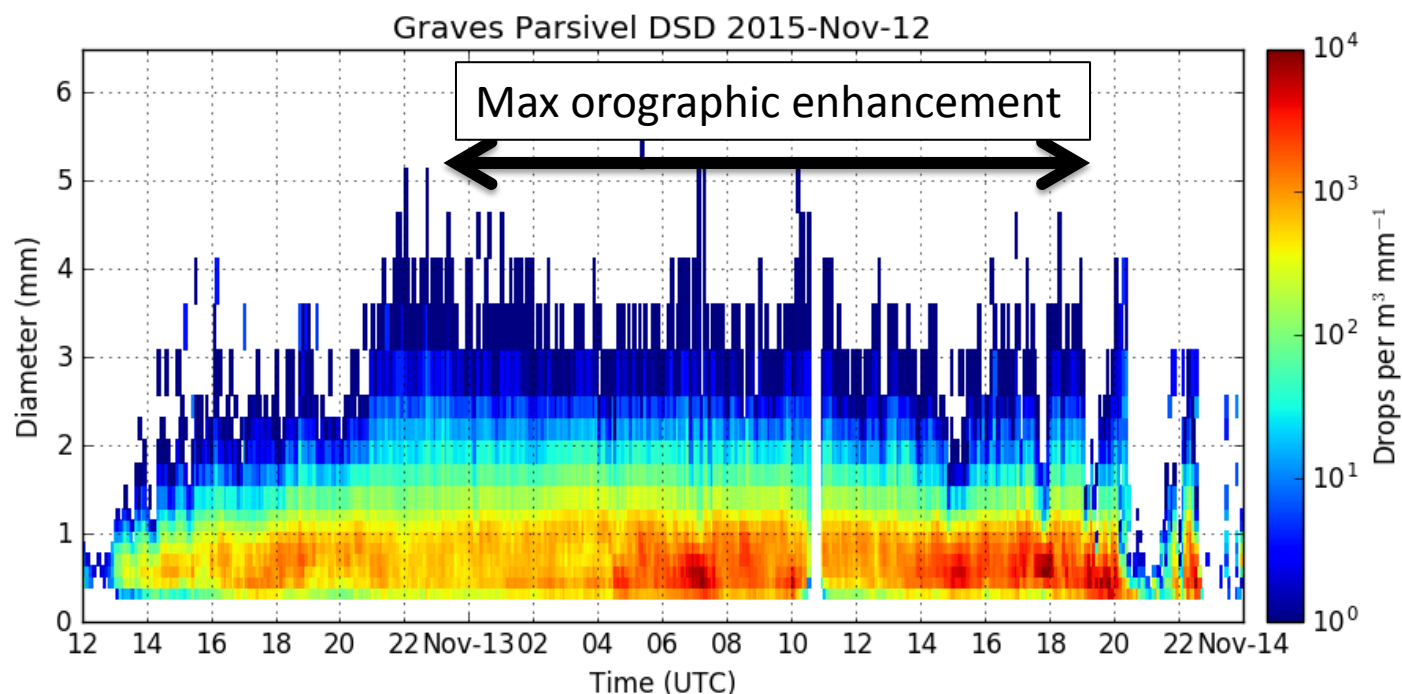




Orographic enhancement associated with large quantities of $< 1.5 \text{ mm}$ drops

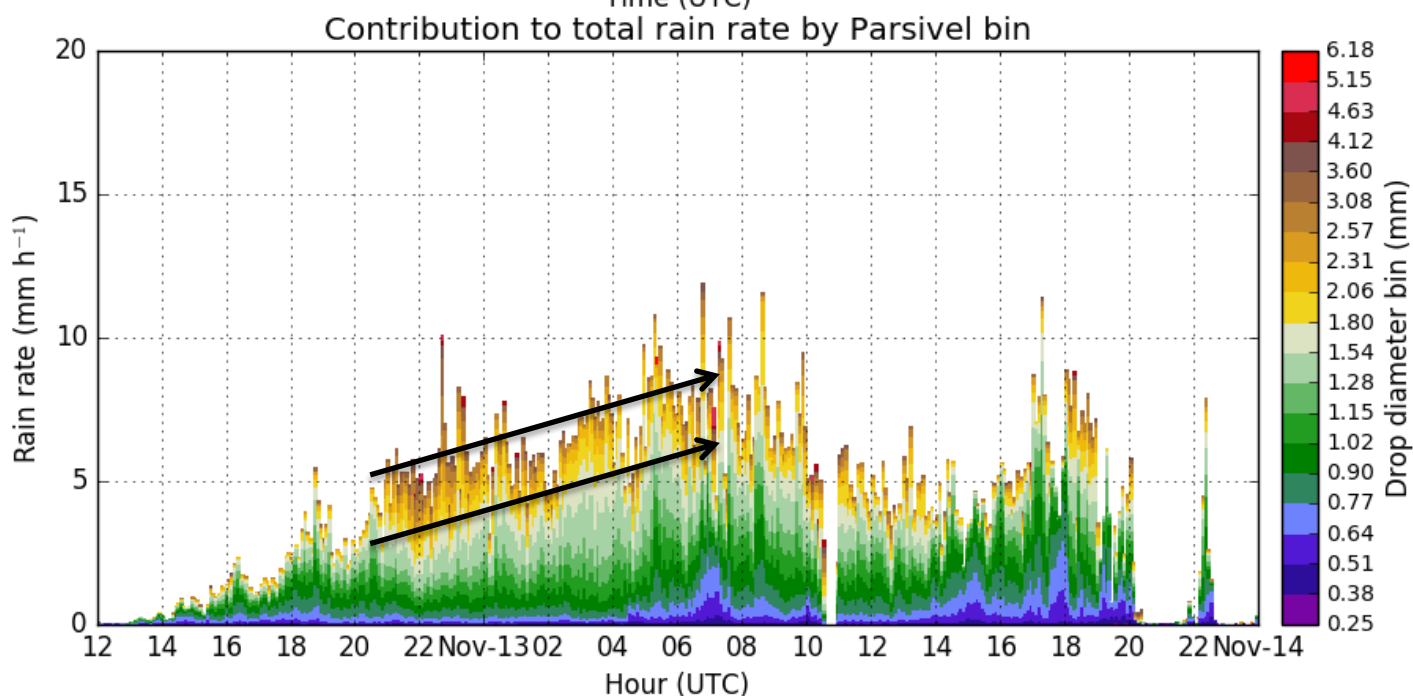


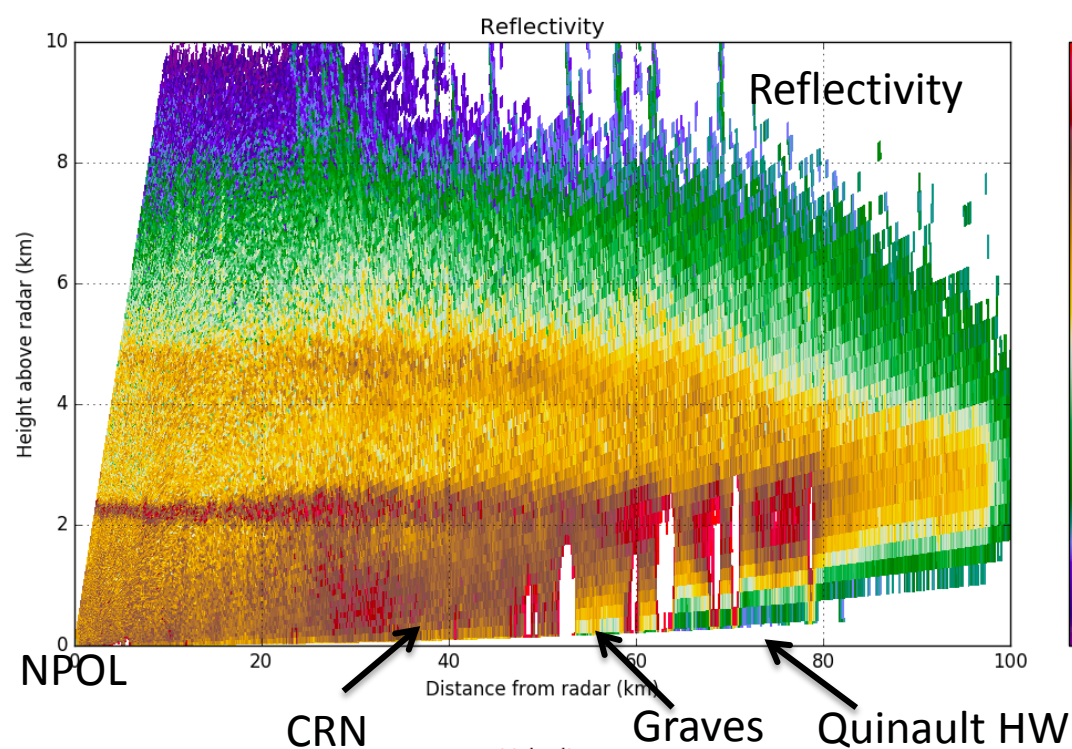
These small-medium sized drops are responsible for the majority of the increase in rain rate



Looks similar, but considerably less drops in all size ranges

Increase in rain rate on 13-Nov is subdued

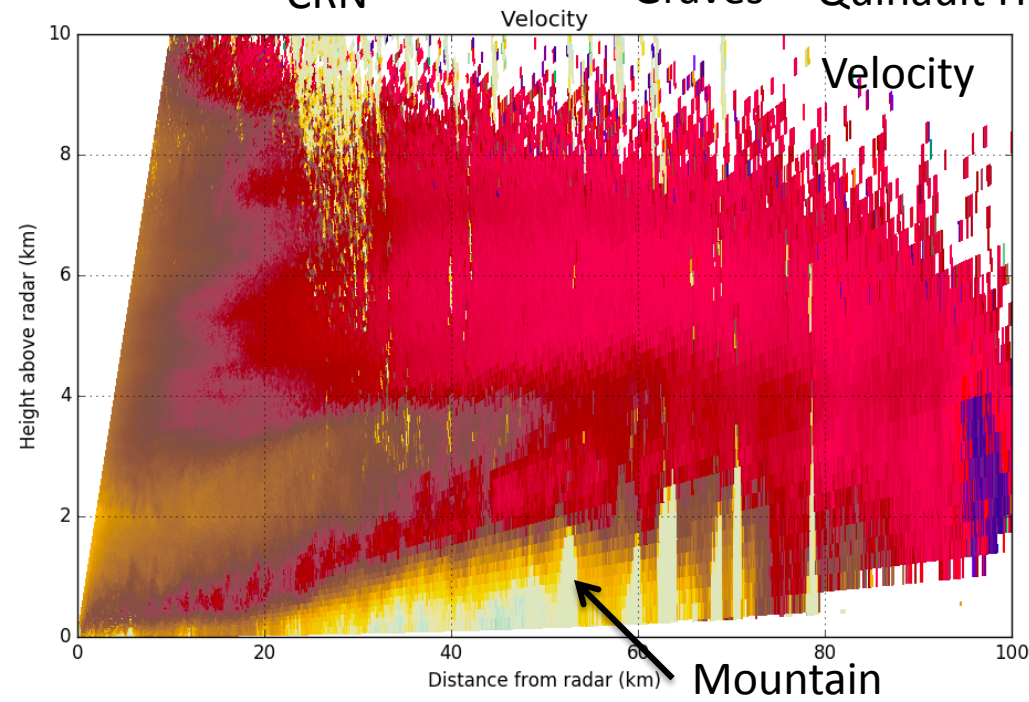




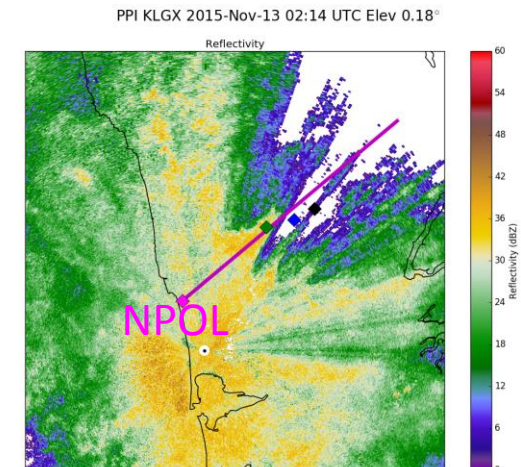
NPOL RHI 13-Nov 02:12 UTC 50° Azimuth

Low-level jet is within 1 km of the surface near NPOL and starts lifting around 20 km from radar (white arrow)

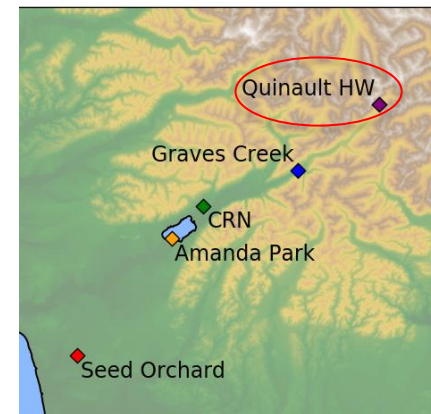
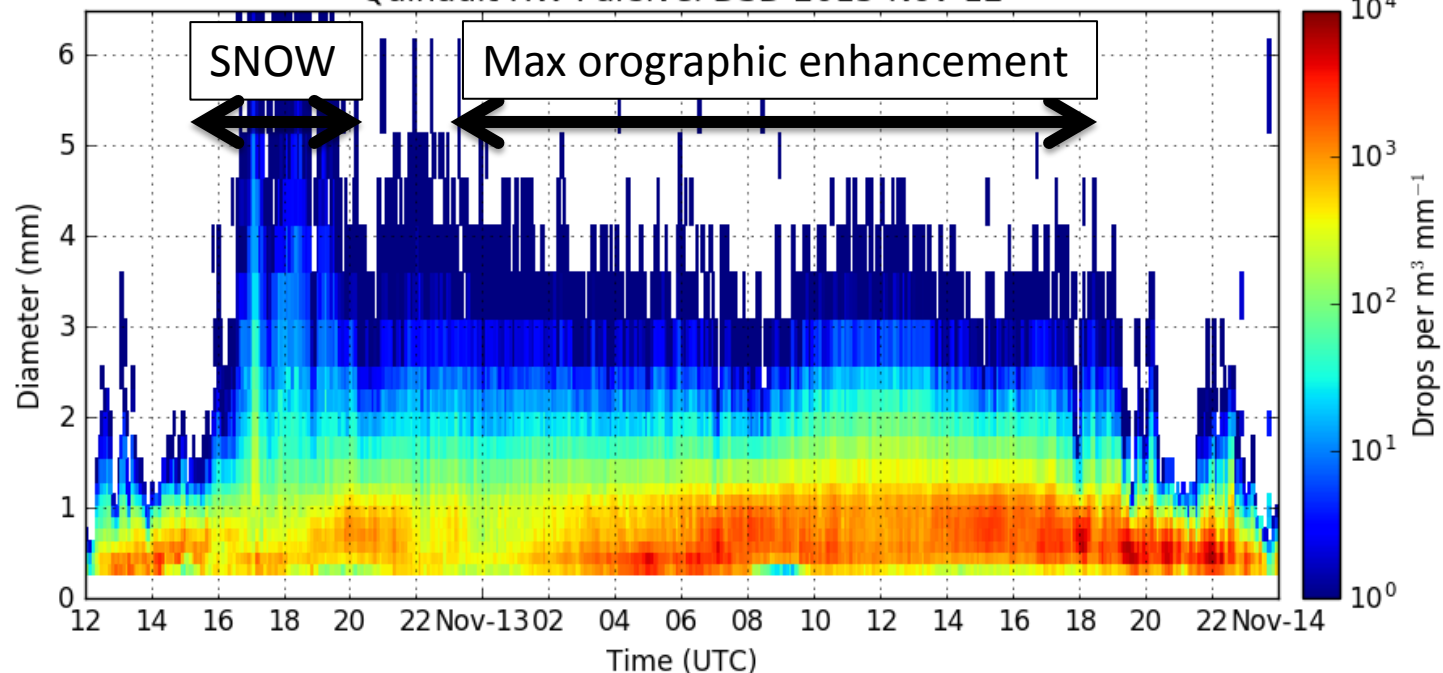
Shear between lower and upper layer is likely enhancing collision/coalescence, allowing drops to grow quickly and fall out.



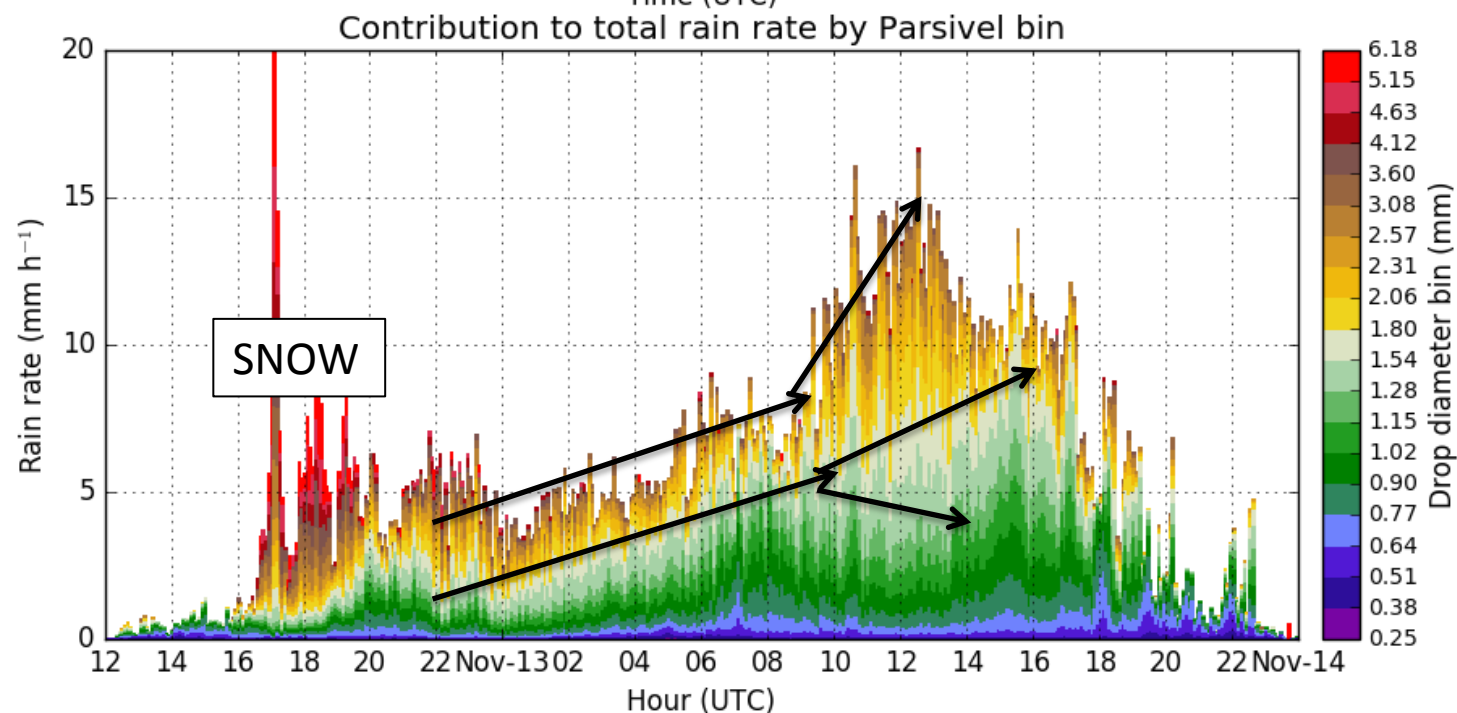
Jet lifting decreases 50-60 km from radar



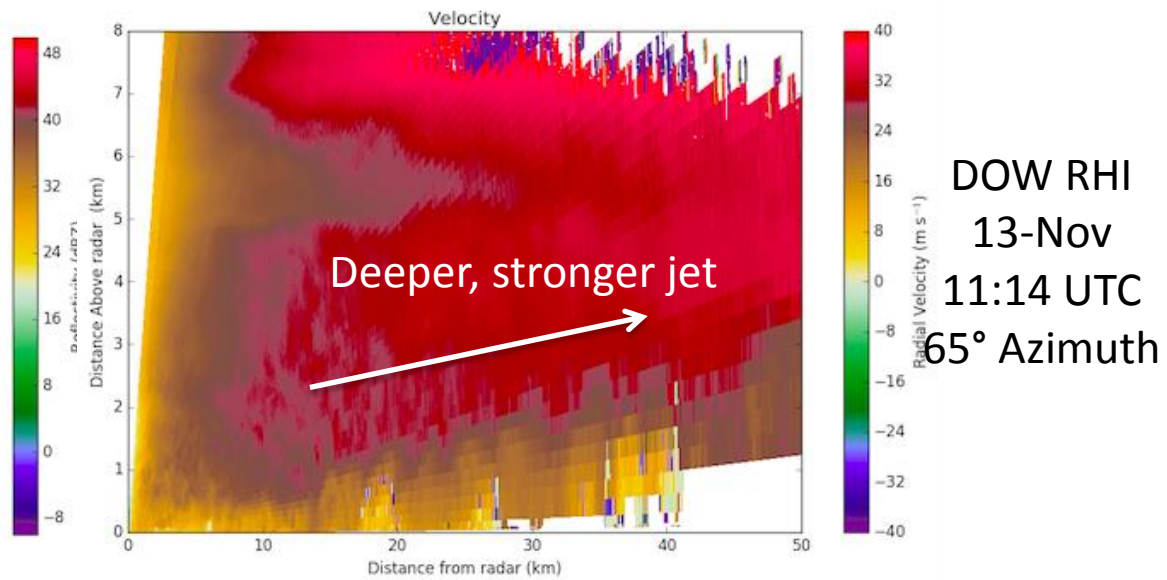
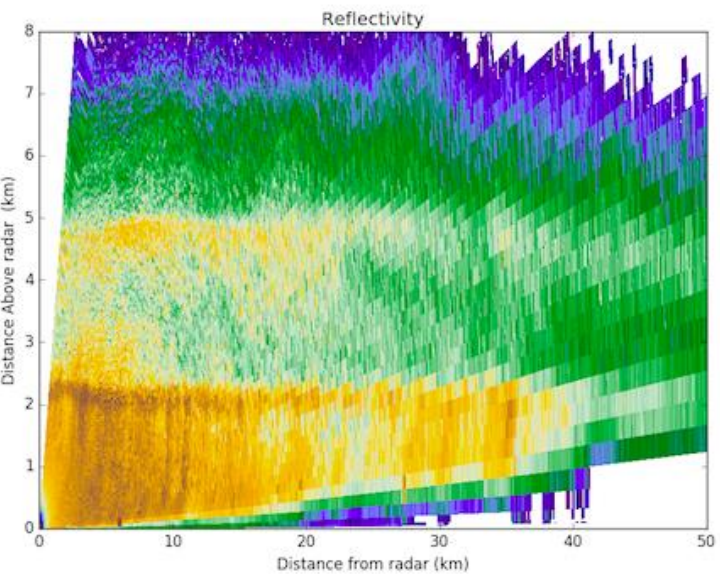
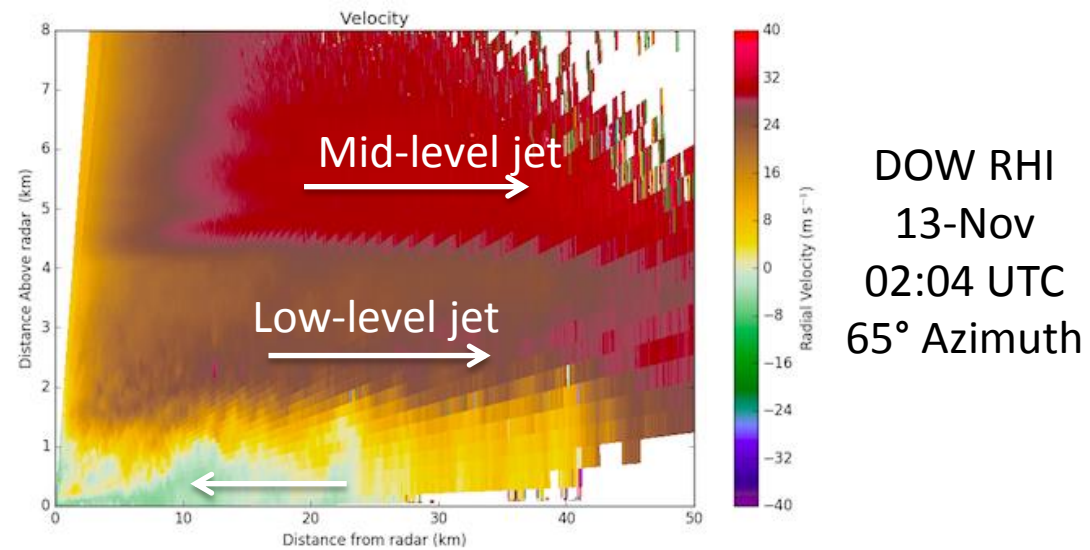
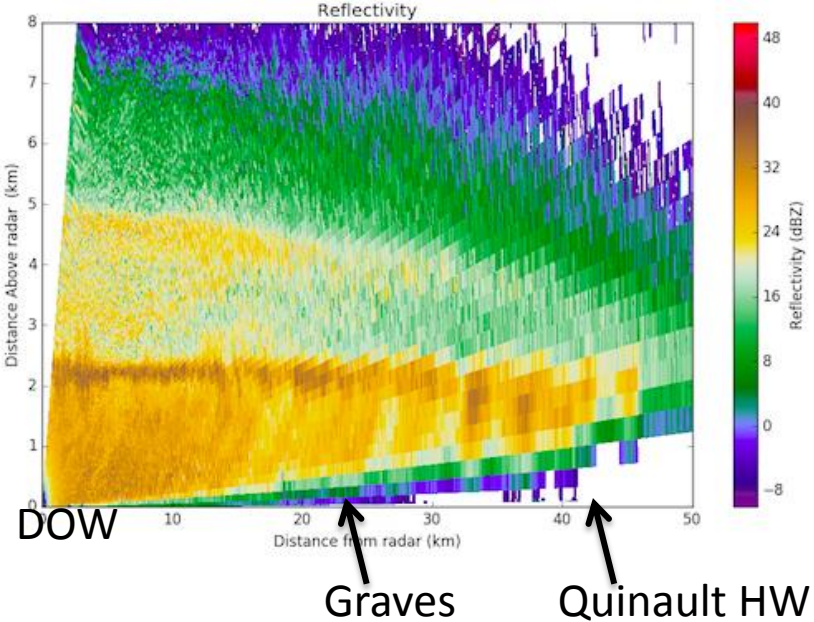
Quinault HW Parsivel DSD 2015-Nov-12



DSD is nearly identical to Graves Creek prior to 09 UTC



After 09 UTC, medium-to-large sized drops account for the increase in rain rate!



Enhancement later in event at Quinault HW possibly related to evolution of low to mid level jet. Appreciable shear is observed between upper and lower layers.

Conclusions

- Strong relationship between lifting of low-level jet and orographic enhancement.
- Depth and extent of lower layer of easterly flow is important for determining location of lifting and max enhancement.
- Jet lifting below bright band enhances drop formation/growth via warm processes. Drops form and fall out quickly in large numbers.
- Role of shear-generated turbulence needs to be investigated further. May be enhancing particle growth both above and below the bright band.

Bonus slides

Dec 03: Significant localized enhancement

OLYMPEX 24-h Precip (mm) 3 Dec 2015

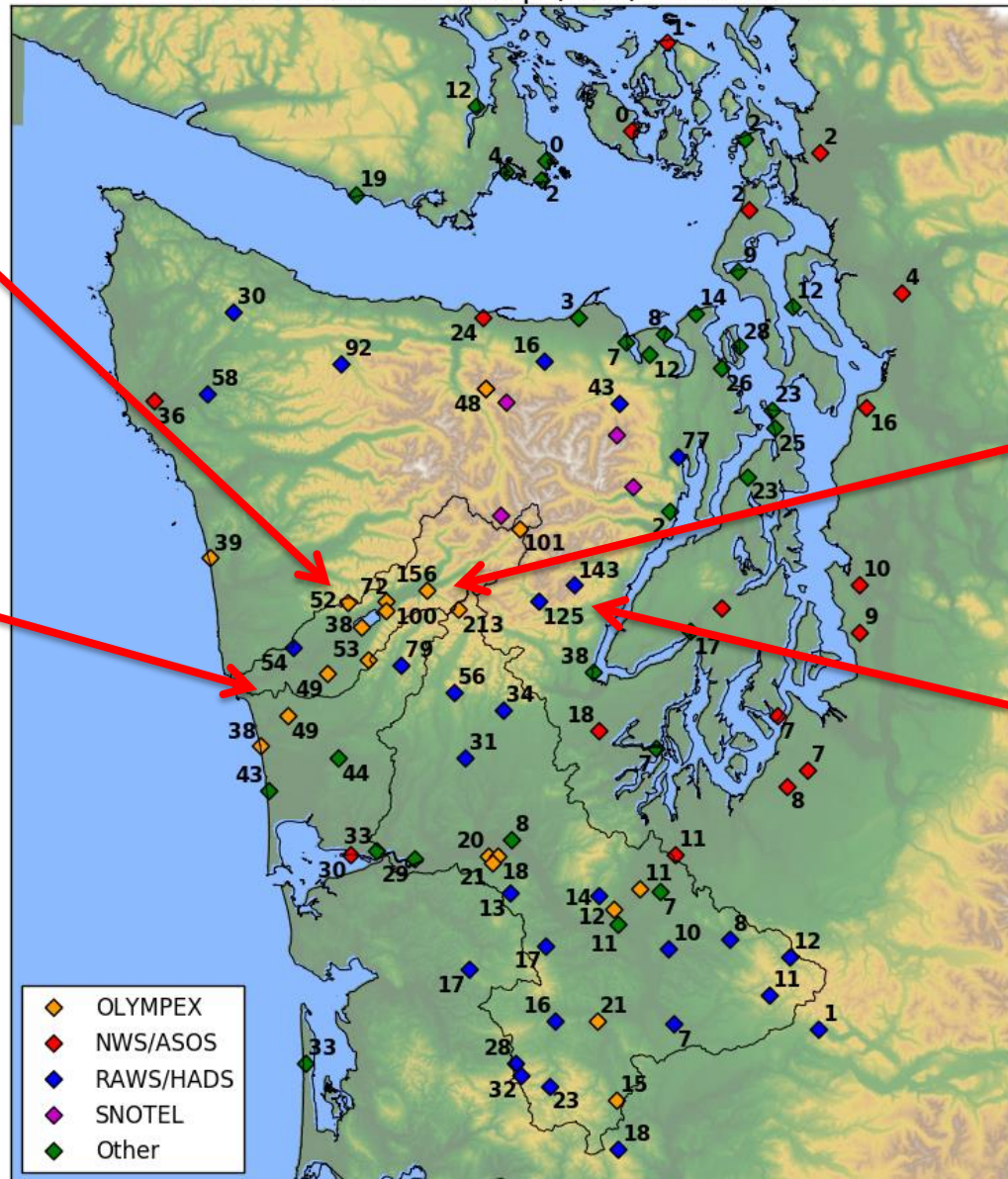
Most totals around Lake Quinault recorded less than 25% as much rain as Nov 12-13 event

Little to no increase between coast and Lake Quinault

Huge totals at a few sites in interior Quinault Valley.

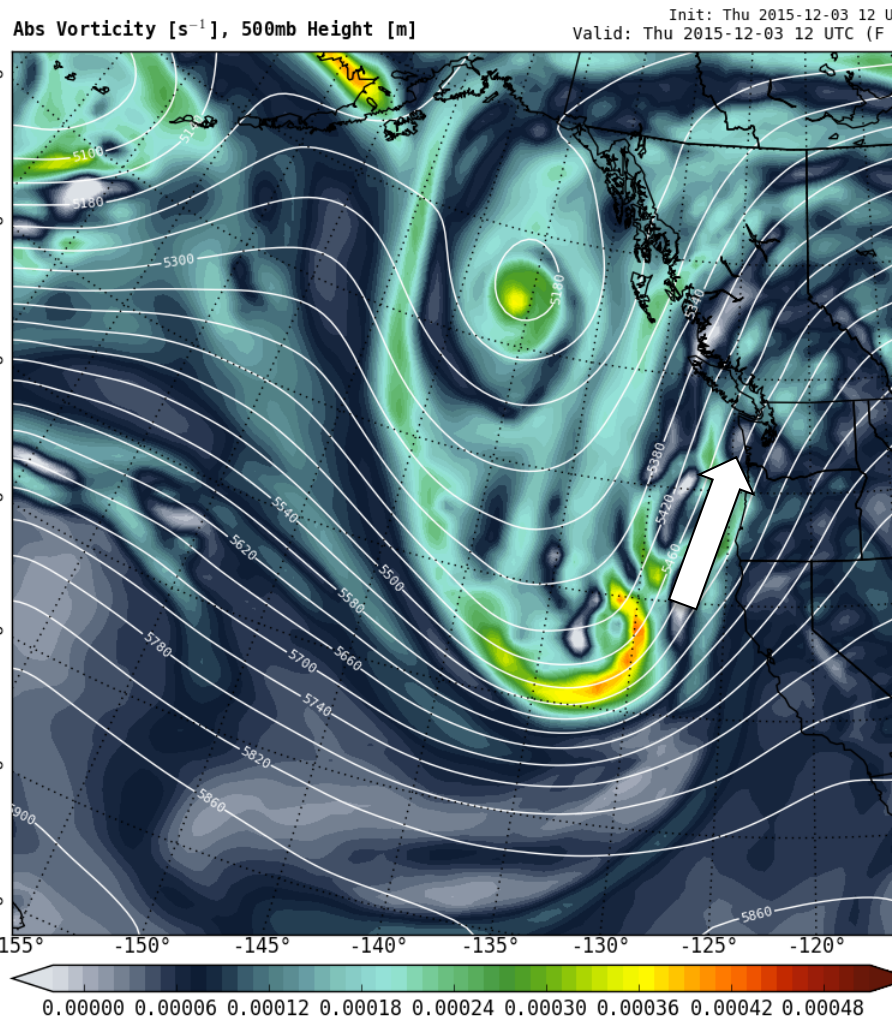
213 mm at 3,400 ft Wynoochee site (80% of Nov 12-13 event)

125-150 mm near Lake Cushman (more than Nov 12-13)

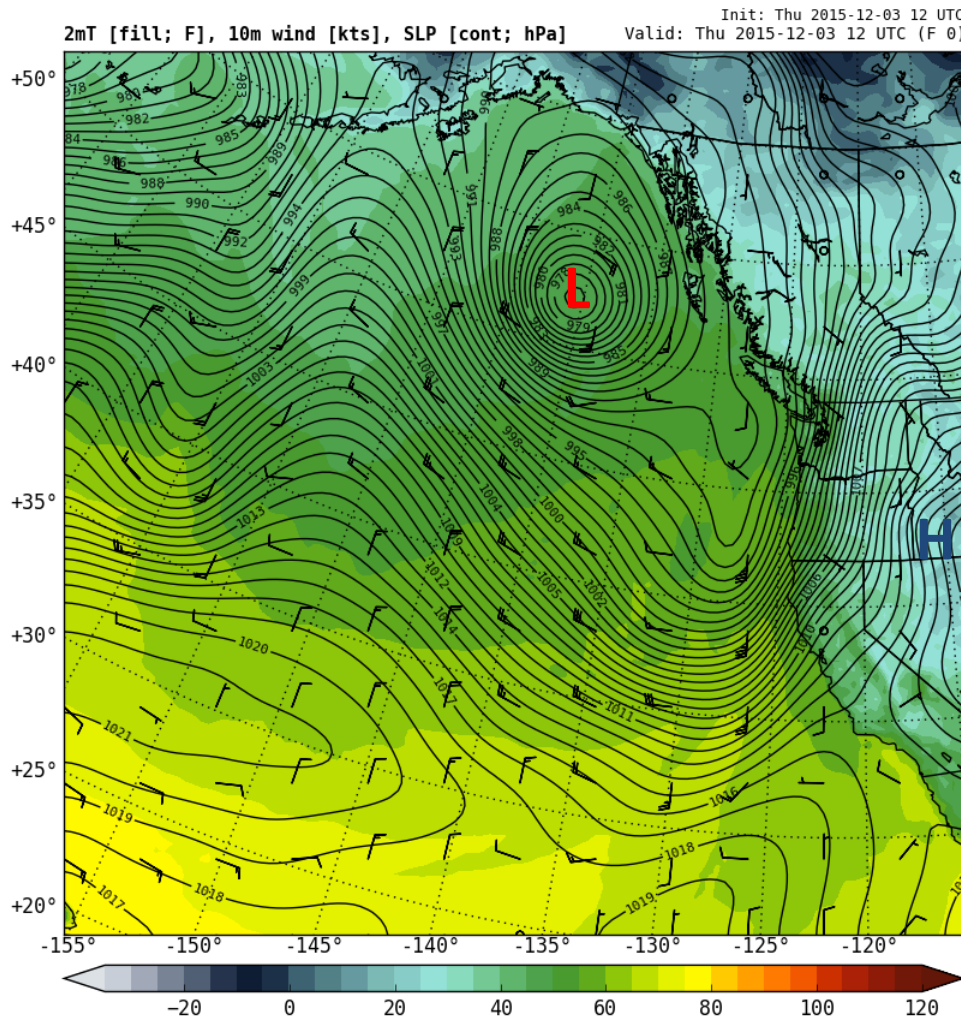


Dec 03 1200 UTC

500 hPa Height (lines), Vorticity (contours)

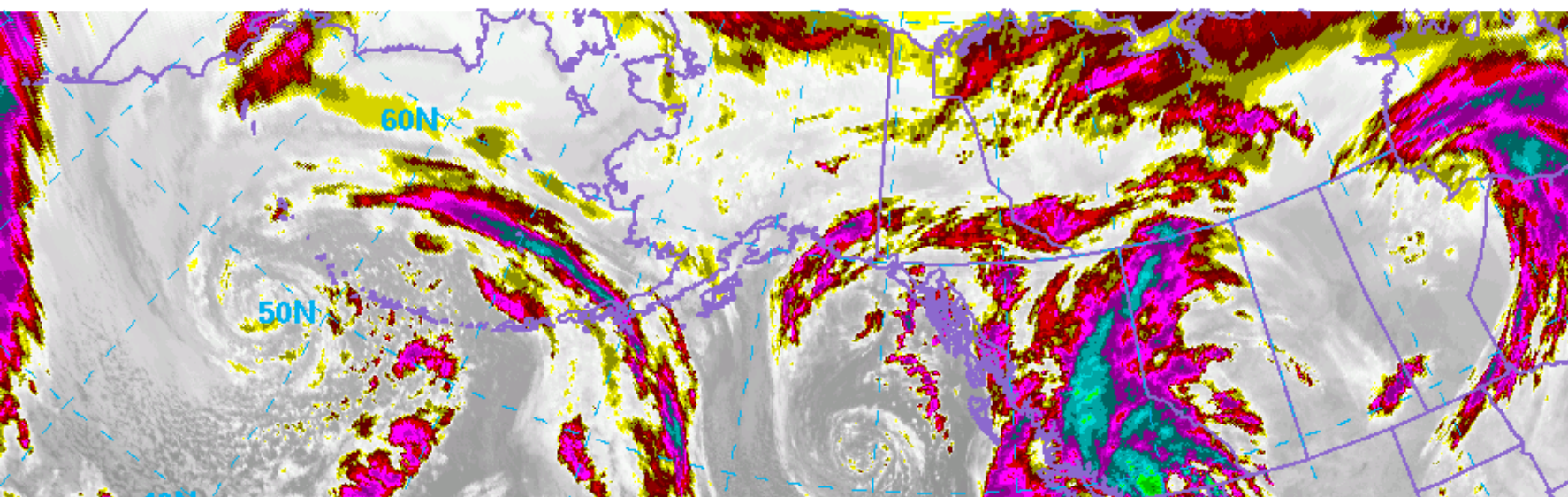


Surface Pressure (contours), Temp (colors)

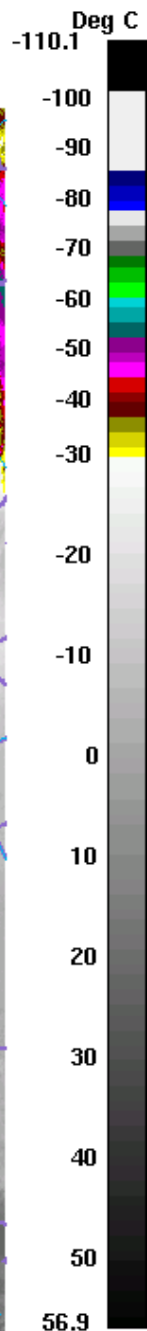
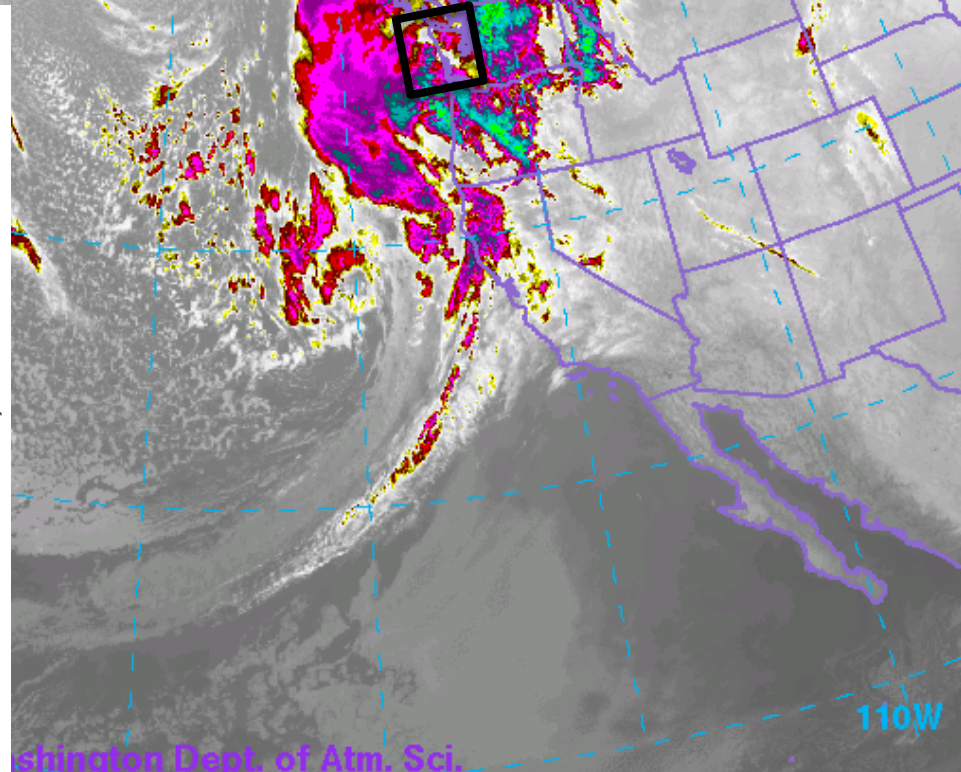
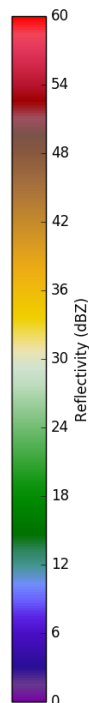
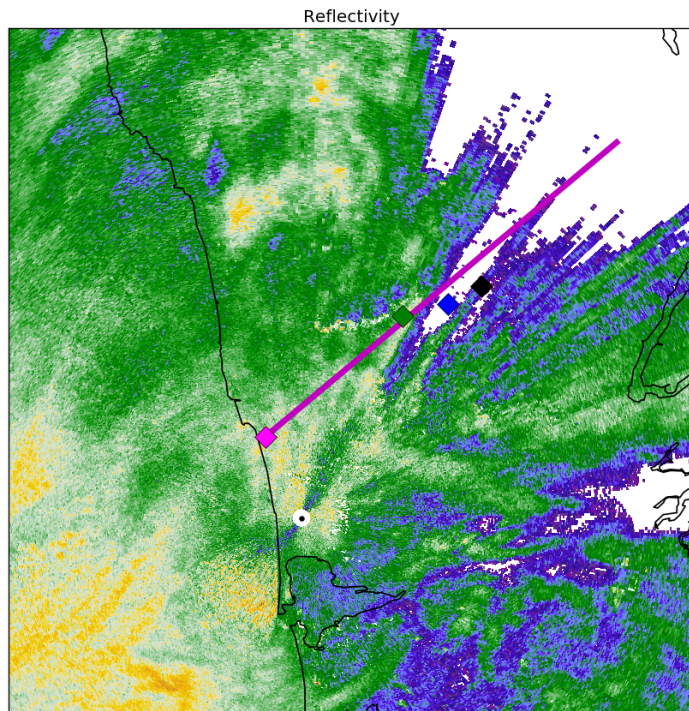


East-west surface pressure gradient favors low-level easterlies.
South-southwesterly flow at mid-levels

IR 12:00Z Thu 03 Dec 2015

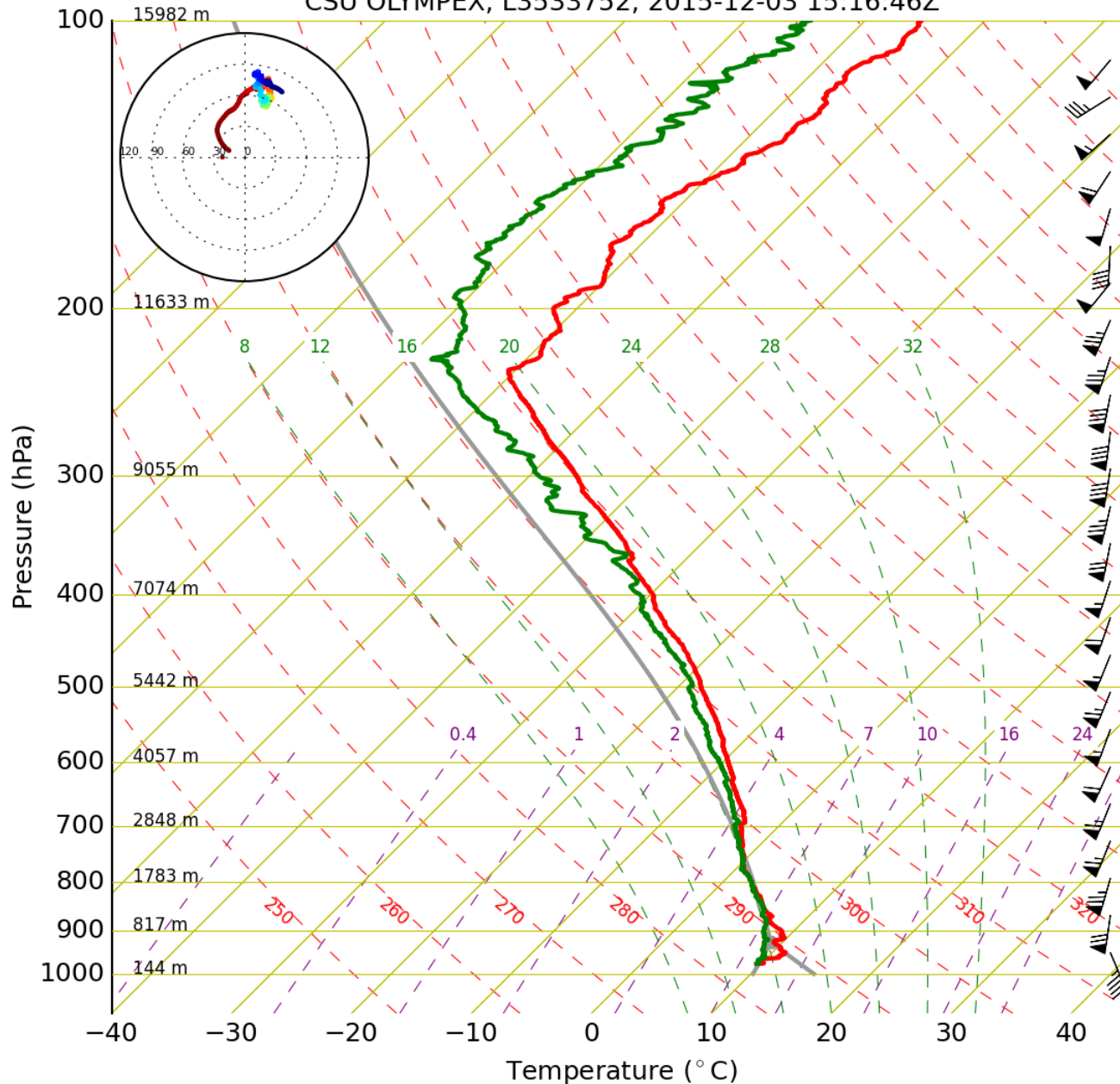


PPI KLGX 2015-Dec-03 12:03 UTC Elev 0.18°



NPOL Sounding 1500 UTC 03-Dec

CSU OLYMPEX, L3533752, 2015-12-03 15:16:46Z



Sounding Params

0° C: 2143 m
-20° C: 5742 m
-40° C: 8351 m
LCL: 64 m
PW: 25.2 mm
6 km shear: 57 kts
Trop: 239 hPa

Surface

P: 976.0 hPa
Ht: 144 m
T: 9.9 °C
T_D: 9.6 °C
T_W: 9.8 °C

70 kt wind at
900 hPa

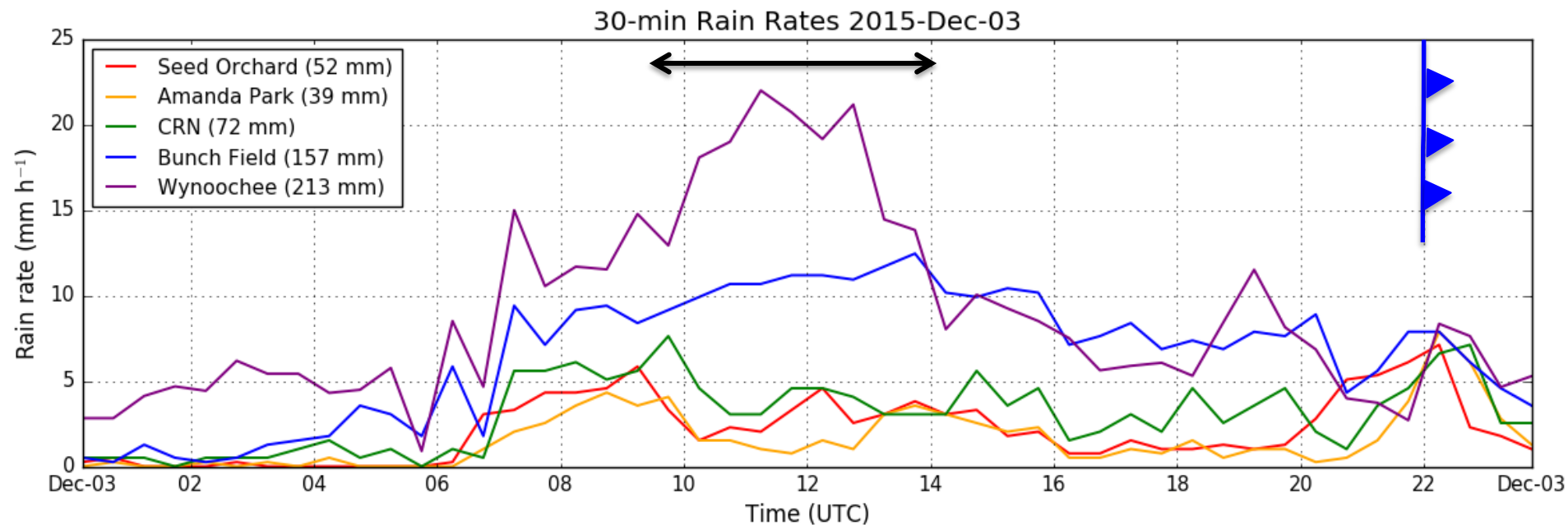
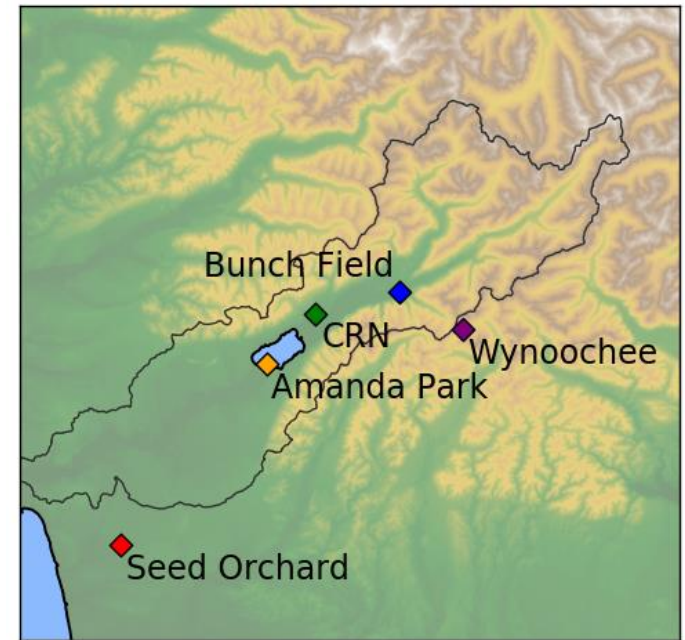
SE flow at
surface

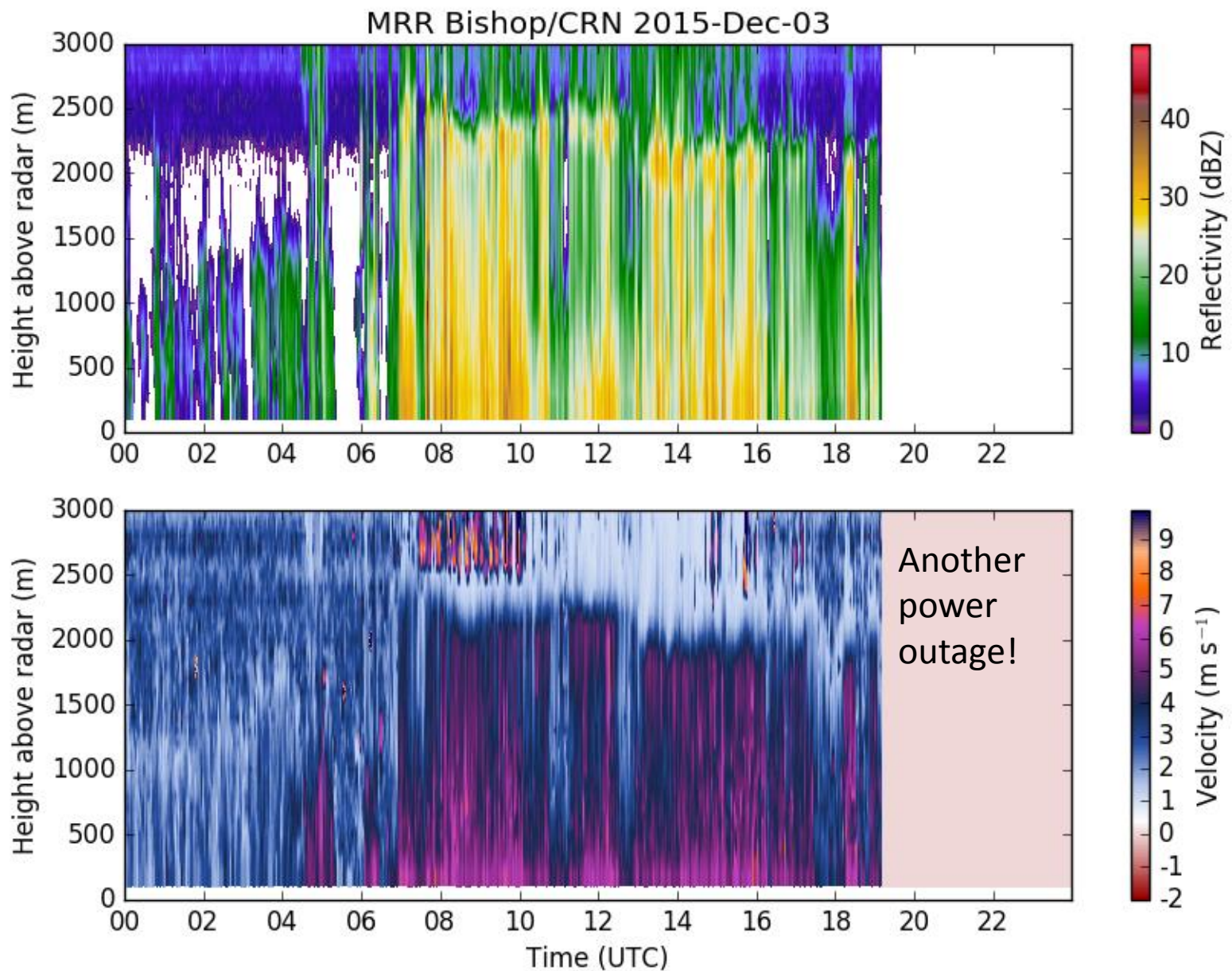
Dec 3

Rain Rates

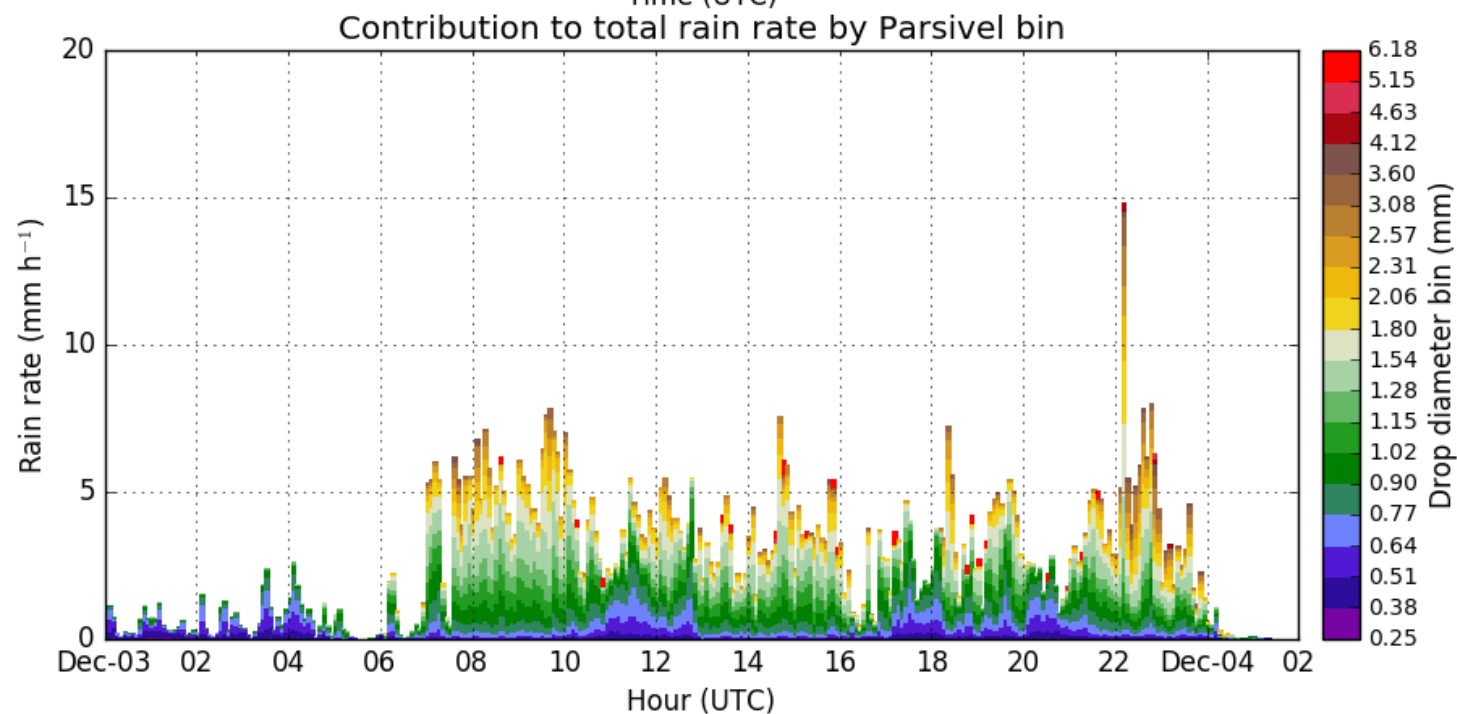
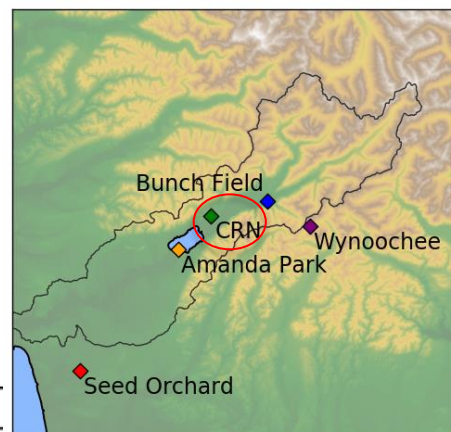
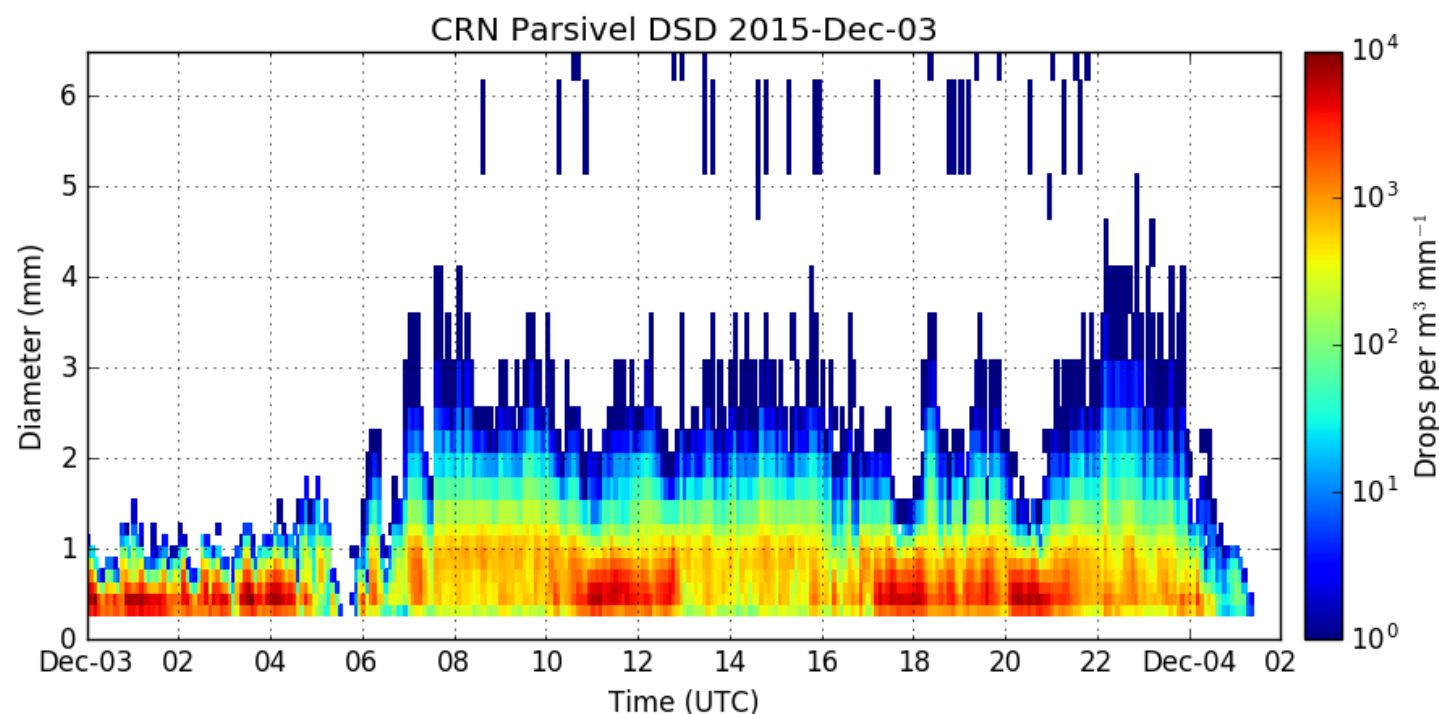
10-14 UTC: Max orographic enhancement

Wynoochee and Bunch Field have highest rain rates by far





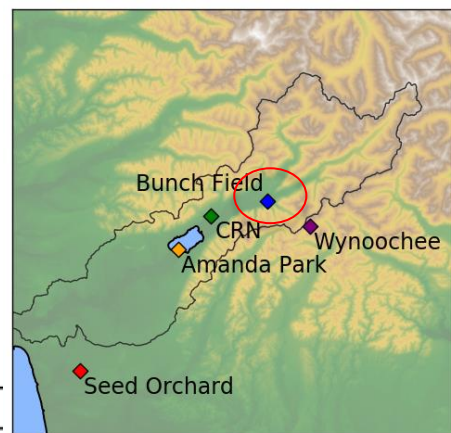
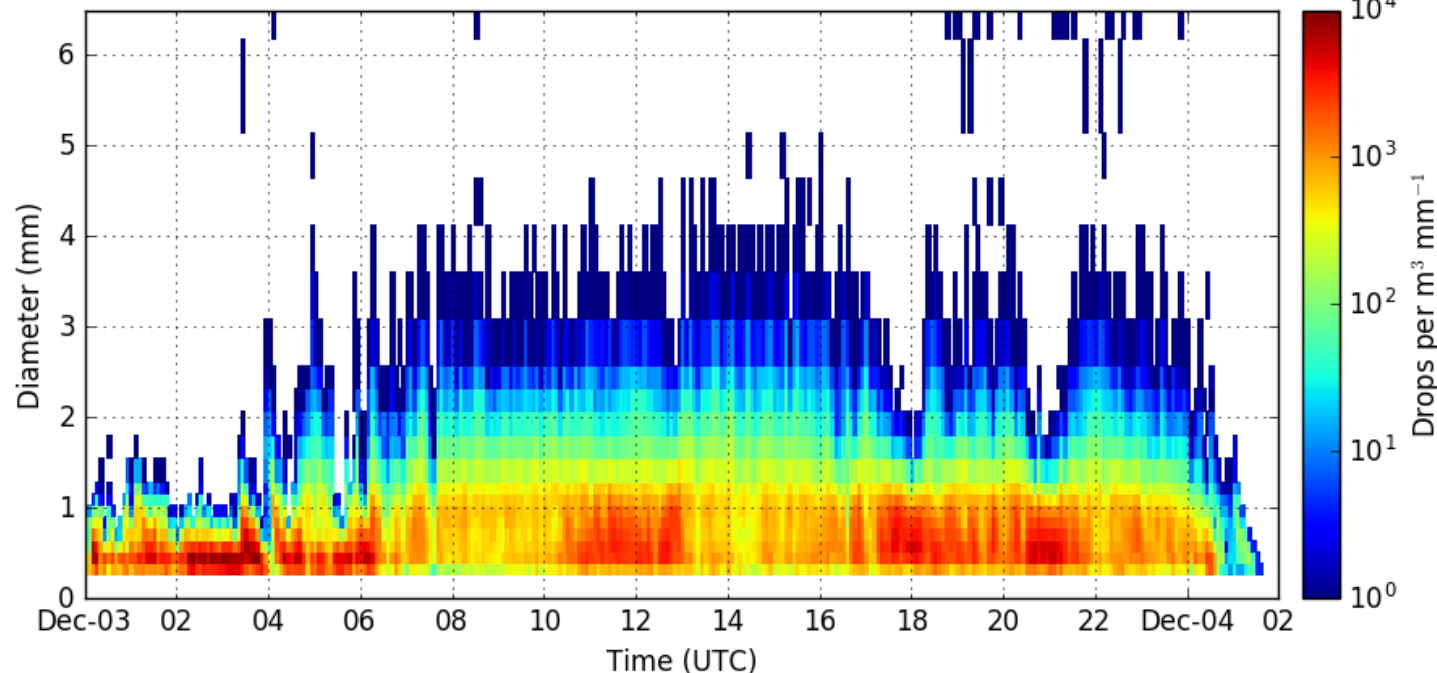
Light to moderate stratiform precipitation, some weak enhancement at low-levels



Overall smaller
size and number
compared with
Nov 12-13

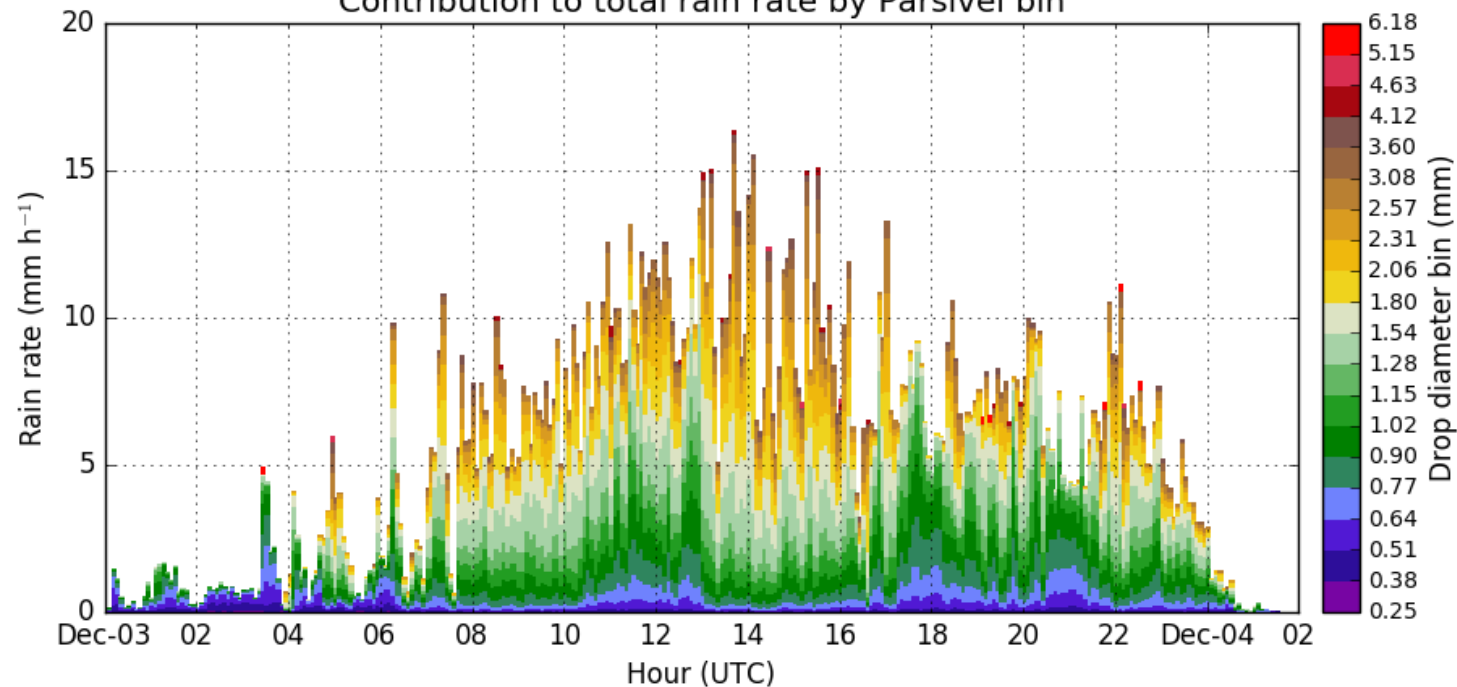
Not much
contribution to
rain rate from
drops $> 1.5 \text{ mm}$

Bunch Parsivel DSD 2015-Dec-03



Similar number of small drops

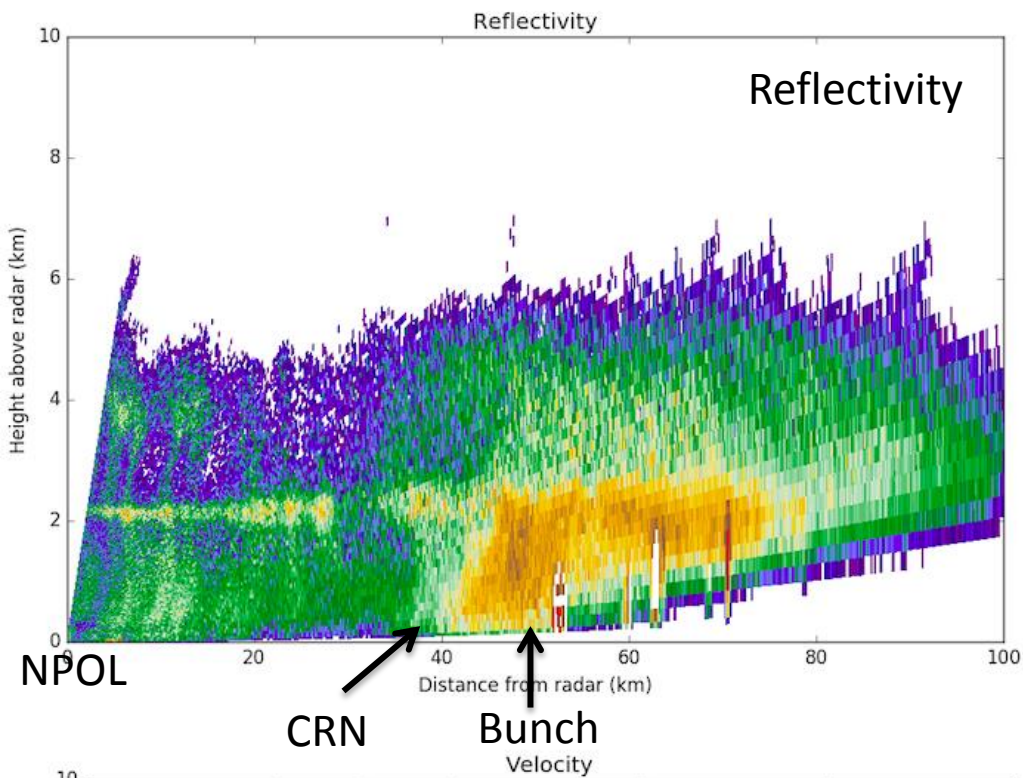
Contribution to total rain rate by Parsivel bin



Significant increase in larger drops > 1.5 mm

Large drops are responsible for most of the 2-3x difference in rain rate

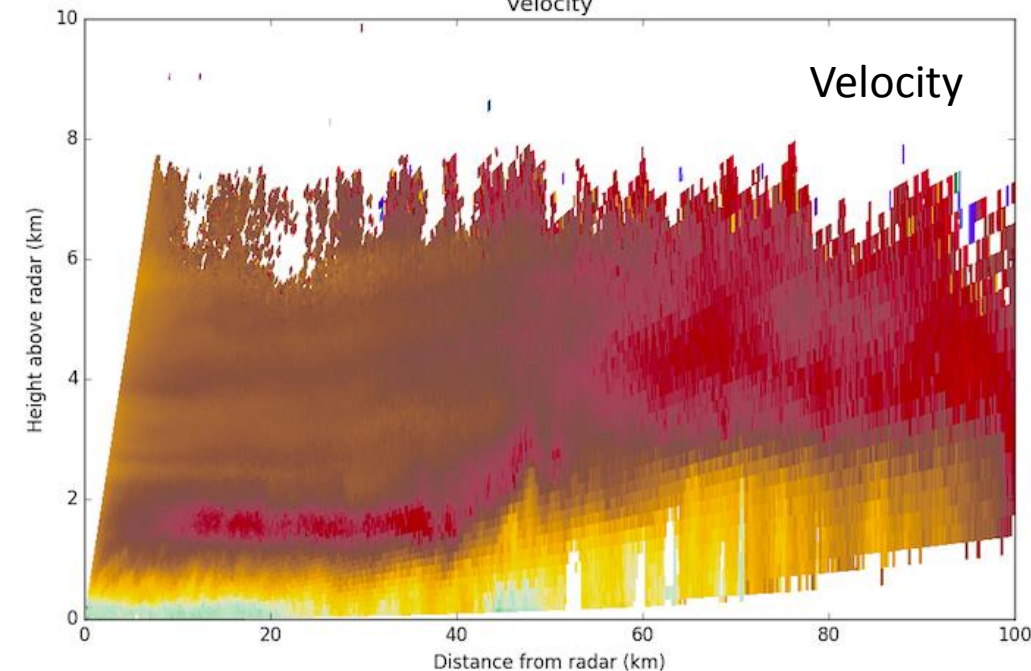
NPOL RHI 03-Dec 11:32 UTC 50° Azimuth



Low-level jet is 1.5-2 km above surface. Jet lifts abruptly when it reaches higher mountains 40-50 km from NPOL.

Strong shear-generated turbulence noted between lower and upper layer—likely enhancing drop growth both below and above bright band

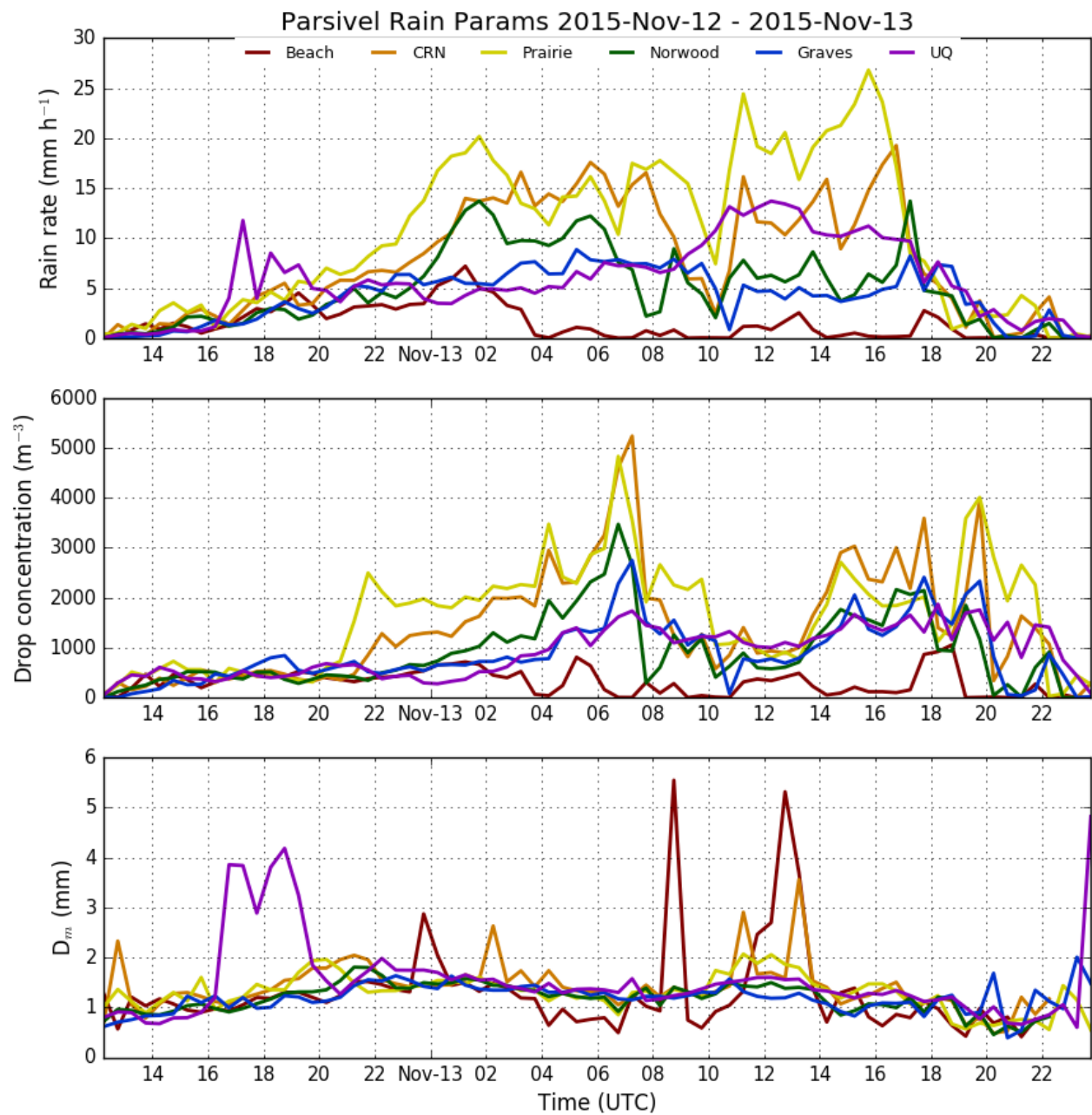
Turbulence may also be enhanced by jet passing over mountains to the south-southeast of Quinault (e.g. Colonel Bob)



Conclusions

- Strong relationship between lifting of low-level jet and orographic enhancement.
- Depth of lower layer is important for determining location of lifting and max enhancement.
- Jet lifting below bright band enhances drop formation/growth via warm processes. Drops form and fall out quickly in large numbers.
- Role of shear-generated turbulence needs to be investigated further. May be enhancing particle growth both above and below the bright band.

Extra slides



Parsivel Rain Params 2015-Dec-03 - 2015-Dec-04

